# CHEAP AND HEALTHY HOMES.

## Opinion of the Director of Public Health, Bombay Presidency.

It was a very pleasant task to read these chapters. When it is realised that they are intended for the average educated middle class man, who may be contemplating building himself a house, it must be admitted that it has been very well done. It often happens that when such books are written, they are either too technical or so elementary as to serve no useful purpose. Most of them are so elementary as to contain many errors, inevitable in such elementary books, and they are on that account liable to perpetuate erroneous notions rather than to inculcate true knowledge. I am glad, your book, as far the chapters on Domestic Sanitation, which I have read, has presented a true version of the facts, which the reader is expected to acquire. There are, in a few cases, instances where the limitations you have set yourself, are likely to lead to misunderstanding. These I have indicated in my remarks* not in a carping spirit of criticism, but with the idea of helping to prevent you from being misunderstood. Although I have a great belief in the efficacy of official propaganda, I am a great upholder of the value of unofficial help, and I welcome the advent of your book as a real advance in that direction. I, therefore, wish you every success in this effort, and hope that your example may be followed by other experts in their own lines, presenting their expert knowledge to the public in the concise, lucid, and helpful way as you have done.

POONA<br>
6th July 1935.

Sd/- A. M. V. HESTERLOW,<br>
Major, I. M. S.

---

* These are printed at the end of the book in appendix No. 4.

# CHEAP AND HEALTHY HOMES

FOR

# The Middle Classes of India



BY

**R. S. DESHPANDE,** B. E., A. M. I. E. (IND.)
ENGINEER, BOMBAY P. W. D.
Author of (1) Sulabh-Vâstu-Shâstra or How to Build Modern Houses, (2) Residential Buildings Suited to India etc. etc.

**FIRST EDITION 1935**



1935

Published by
R. S. Deshpande, B. E., A. M. I. E.
at Kopargaon, Dt. Ahmednagar.

Printed by
Anant Vinayak Patvardhan,
Aryabhushan Press,
936/3 Bhamburda Peth Poona, 4.

## PREFACE.

Some apology is needed for writing this book in English instead of in a vernacular of India, in which it would have reached more directly, the hands of the class of the people for whom it seeks to cater. This is quite true. But it is equally true that on account of so many different vernaculars in India a book written in English is sure to approach a greater number of readers in all communities distributed over all parts of the country, than one published in half a dozen important vernaculars together. Again, translating and printing it into so many vernaculars would entail great trouble and expense. Again, if the writer is really so fortunate, as he has been in the case of his previous publication, that a demand in some vernaculars is received, it is much simpler to secure the services of the best men to translate it into those vernaculars through the medium of English than through that of any Indian vernacular.

It was originally intended to include farm houses, barns, silos. stables and cow-sheds etc. in it, but as the book assumed a concrete form it was realised that they form a separate class by themselves, and if the writer has the good

luck of receiving a warm welcome in the case of this book also, he will not be slow in publishing one such book on the problems of rural housing.

The first 178 pages, or a little more than half of this book has been devoted to practical hints on economy by suggesting different alternative methods of construction in sequential order from the collection of materials and foundations, to the completion of the roof, with a close attention to securing the best of sanitation and comforts. Several alternative methods have to be suggested and the responsibility of choosing the most suitable one has to be thrown on the lay reader, because it is impossible to lay down definite rules or prescribe particular methods in this vast continent of India with extreme variation not only of climatic conditions, but also of building practice, and materials available which make every difference even in the architecture of the place.

Still as the habits and social customs affecting the general sanitation of the community are not so varying, it was possible to set forth a few rules and make practical suggestions with some precession for the improvement of the sanitary conditions, which occupy the latter half of the book. Some apology is, however, required that the writer was forced to abridge and print in a small type in an appendix,

the chapter on such an important subject as Epidemics and the duties of a house-holder in preventing or fighting them, for fear of increasing the bulk of the volume.

To solve the problem of housing on economical lines, the efforts of one or two individuals are not sufficient. It requires the application of many brains, particularly to get over the difficulties as they present themselves in the extraordinarily varying conditions of the different provinces. The writer has endeavoured to do his bit in his own humble way.

Concrete has great potentialities before it in the future in forming part or the whole of the building, especially in view of the facts that gravel and clean river sand are available in any quantity in the rural districts for the cost of mere collecting, that with rapid increase of motor traffic the facilities for the transport of cement are fast developing, that indigenous cement of the best quality is becoming cheaper every day, and that the most efficient organisation of the Concrete Association of India is always ready to give free advice in whatever matter concerning the use of concrete. But so long as simple block-making machines have not come within the reach of the cottage builder either for a cheap cost or for a small hire, that stage has not arrived and the writer has to content himself with making suggestions here

and there where its use even at this stage makes for economy and efficiency.

The writer would be failing in his duty if he did not mention the great help and encouragement he has received in the compilation of this volume from numerous friends and well-wishers, amongst whom he must acknowledge with grateful thanks the assistance received from Mr. B. B. Kamat, Head Master, Northcote High School, Sholapur, and Mr. M. B. Sant, Inspector of Education, (retired), Dhar State, C. I.

I cannot adequately express my debt of gratitude to Major A. M. V. Hesterlow, I. M. S., Director of Public Health, Bombay Presidency, for having gone, very carefully, through the chapters on Domestic Sanitation and appendix No. 2, and made very valuable suggestions, which have been included in appendix No. 4 at the end of the book.

It is earnestly hoped that the book will supply the long felt need and receive a warm appreciation of the public.

1st August 1935. R. S. DESHPANDE.

# CONTENTS.

## LIST OF BOOKS CONSULTED


(1) Practical Building Construction—Allen.
(2) Building Construction Parts 1 and 2—Rivington.
(3) Roorkee Treatise on Masonry.
(4) do do Section 1 Building Materials.
(5) do do Section 2 Building Construction.
(6) Farm Buildings—Foster and Carter.
(7) Cottage Building in Cob, Pise, Chalk and Clay—William Ellis.
(8) Unit System of Farm Buildings—Henderson.
(9) Economy in House Building—Dunn.
(10) Modern Building Vols. 1 to 6—Searles Wood and Adams.
(11) Standard Type Buildings of the Forest Department—Pipe.
(12) Plans and Specifications—Mirams.
(13) M. E. Service Handbook Vol. 2.
(14) The Country Life Book of Cottage—Weaver.
(15) Lutyen's Houses and Gardens—Weaver.
(16) Conservation Manual—Marshall.
(17) Introduction to Scientific Study of Soils—Comber.
(18) Physical Properties of the Soil—Bernard A. Keen.
(19) Soils, their formation properties etc.—Hilgard.
(20) Concrete for Farm House and Estate—Ballard.
(21) How to Make Good Concrete—Concrete Assoc. of India.
(22) Indian Concrete Journal—Concrete Assoc. of India.
(23) R. C. Designer's Handbook—Reynolds.
(24) Concrete Cottages, Bungalows and Garages—Lakeman.
(25) Sanitation in India—Turner and Goldsmith.
(26) Hygiene and Public Health—Ghosh.
(27) Manual of Vital Statistics—Munsiff.
(28) Our Homes—Murphy.
(29) Roorkee Treatise on Sanitary Engineering 2 Vols.
(30) Bombay P. W. D. Handbook
(31) M. E. S. Handbook Vol. 1.
(32) Sir Gangaram's Pocket Book of Engineering.


The author is deeply indebted to the authors of the above books.

# INTRODUCTION.

*Naturalists tell us that the duration of the life of an animal must be normally five times the period it takes for the full development of its growth. This has been amply proved in the case of lower animals. If we observe the domestic animals, such as the horse, dog, cow, goat etc., we shall find that they live almost the full span of life ordained to each by Nature. But if this principle is made applicable to human beings, we find that we are disappointed. Man possesses a very superior mental organisation and power of reasoning over the brute creation. He has utilised this to the fullest extent and devised means of defence to protect himself from the fury of elements, by building houses, lighting fires, making clothes, cooking food and so on. He is thus expected to live longer than 105 years, i. e. five times the period of 21 years, which he takes for the full development of his skeleton. But what do we

* "*Comparative Longevity in men and the lower animals*" by Si E. Ray Lankester.

actually find? The average span of life of man, even in the civilised countries of Europe, was, until two decades ago, only 42 years! But by careful attention to sanitation and rules of hygiene it has, of late years, been increased. Still it does not exceed 51 years! In India it is less than half of this, viz. 21 years! This, in other words means, that the average Indian succumbs to death when he is just on the threshold of maturity!

What is the reason? There must be some grand destructive agencies at work which shorten the human life. What can they be? If we observe minutely, we shall find that though man is subject to many diseases, from which the lower animals are exempt, for instance, certain diseases of mind, diseases descending from heredity, diseases caused by indulgence in vices or luxuries, contagious diseases etc. he, in his very attempt to out-wit Nature by devising means of defence such as building houses, villages, towns, etc. has created around him conditions most conducive to diseases, which are responsible for shortening his life. Thus Malaria, Typhoid, Anæmia, Tuberculosis, Neuralgic diseases, Cholera, Plague etc., which take annually such a heavy toll of human life, owe there origin entirely to deficient light and ventilation, to damp, and to general insanitary conditions in and around our habitations.

That malaria, plague, cholera and other diseases should make their abode permanently in India, should in no way be surprising to those who know that the most fundamental priciples of domestic sanitation and personal hygiene are set at naught either through ignorance or slovenliness or both.

The following description of an average house in an Indian town will throw light on the causes of high mortality in India.

It is a house, owned, not by a poor man, but a well-to-do money-lender, situated in the heart of a town, lining one of the main thorough fares, which is, by the way, only 12 ft. wide. It consists of threestoreys, each having a separate tenement of three rooms. The ground floor tenement is occupied by the owner. All the three rooms are six ft. wide and are one behind the other. The front room is 12 ft. long and is occupied by the business office of the banker and contains a moderate sized steel safe, two almyrahs, a chair, and two desks with mattresses in front, to squat upon. The central room is only 10 ft. by 6 ft. and is lit up by the diffused light penetrating through the door openings and a small horizontal window near the ceiling in the partition wall. This is the only bed room of the family. The third room in the rear, almost of the same dimensions, is the kitchen, with a sink, which is used both

for slop water and bath, and also serves as an emergency urinal. The sink consists of a large slab at the bottom and rough stones on the sides, once laid in bad mortar which, however, has now been washed away, leaving wide crevices and thus making the side stones loose. It was intended that the water and urine from the sink should go to a pit close by, in which a sort of Aroidoe plant (Alu अळु, Marathi) which is used as a vegetable, is grown, but the water soaks just near the wall and never reaches the pit, causing damp to rise both in the floor and up the wall. Only the front room is paved, the other rooms have only a mud floor. The rear wall has a small window, but it is normally closed by day for fear of draught and by night, for fear of thieves. There is a small open space in the back yard, in which there is a latrine built of mud walls and mud floor. A steep staircase descends from the upper two storeys to the latrine as this is the only latrine for the benefit of all the three tenements. Another corner of the space is occupied by a cow-shed which has a mud floor and corrugated sheet roof which rests on the compound wall raised on the back side and on wooden posts in the front, which is open. Between the cowshed and the kitchen there is a well for drinking water, 4 ft. in diameter with a winch and rope for drawing water. The parapet

of the wall is low and when bathing and washing is done on a flat stone placed in front, there is every chance of the soiled water flowing back into the well. A drain from the well in earth leads the waste water from the well to the pit for the aroidoe plants referred to above. Between the kitchen and the latrine there is a muck-heap on which all sorts of rubbish such as sweepings from the house, garbage of vegetables, waste fodder from the cow-shed, leavings of food etc. are indiscriminately thrown. The children of all the three tenements make a free use of the surrounding space for answering the calls of nature, their excreta being left for the sun to dry. Whatever space remains over and above this, is utilised for making cow dung cakes; even the parapet wall of the well and the rear wall of the house is occupied by them. There is a lane barely 4 ft. wide behind the latrine for the sweeper to scavenge. The bed of the latrine is at a lower level than that of the lane, and therefore, liquid sewage stagnates in it to a certain depth. There are no shutters to the sweeper's door of the latrine on the rear side, therefore, swarms of flies settle on the liquid sewage and fly from there and from the muckheap directly into the kitchen to sit on the cooked food for a change. The condition of the latrine can not be adequately described; suffice it to

say, that it is used carelessly by the occupants of the three tenements and its mud floor is never cleaned by any body.

The pit in which the Aroidoe plants are grown is a breeding place and nursery of mosquitoes.

The occupants of the ground floor are ten in number including six adults and four children. During the night, beds are huddled up as the space would make it physically possible in all the three rooms. In addition to this, some room is made available for the calf, by the side of a bed, to avoid a chance of the cow's milk being sucked by it, if it were tied in a corner of the cow-shed. As one can naturally expect, the house is full of bugs and fleas, whom mosquitoes aid in busying themselves during night in disturbing sleep of the inmates. No nets are used. Rats confidently move about even by day.

In front of the house there is a Municipal dust-bin which is never properly used by any-body and is always overflowing. In stead of the dust-bin holding *Kutchera*, apparently the heap of the latter holds the dust-bin. Children of the neighbouring houses, who have no open space enclosed in their compounds, commit nuisance near the dust-bin. The rows of houses on both sides are three or four storeys high, and prevent the genial rays of the sun

penetrating the houses during any part of the day.

This is no fanciful picture, nor one over-drawn, but a faithful one, depicting every day life in the average village, town, and city in India. The poverty striken people are still worse off than this, living in the slums of cities, where overcrowding is far greater than shown in the above instance. To quote the Census Report of 1931:

"At least 36 p. c. of Bombay's population suffers from gross over-crowding. For, of all the tenements in the city, 81 p. c. have only one room with an average accommodation of four persons. 2,56,379 people live in rooms occupied by 6 to 9 persons, 80,000, in rooms occupied by 10 to 19 persons, and, 15,000, in rooms, 20 or more, making a total of 3,51,000 and odd or 1/3 population of the city."

1/3 population of the 2nd city in the Empire living like lower animals or even worse!!

Is there worse degradation imaginable? What wonder if one epidemic after another makes ravages from one end of the country to the other!

Pious expressions of horror at this are of no avail. Those who have a real sympathy and a sincere desire to help, must translate it into action and the sooner it is done, the better.

It was this that set the writer think about and search after means to secure two things: (1) Cheapness and (2) Sanitation. He soon found that the efforts required for the attainment of the first object must be oriented in the following directions :—

(1) Elimination of transport, which is synonymous with utilisation of local meterial to the maximum extent.

(2) Employment of local labour, and that too, of unskilled labour as far as possible.

(3) Cheap materials.

Our wise forefathers knew this very well. Because, nearly 90 p. c. to 95 p. c. of our old houses, whether in villages, towns, or cities have been built of stone or brick in mud, or in some instances only in mud, with a free use of timbers and other materials produced locally in the main. The craze for lime and cement for cottage building on the part of the poor, is modern, and is restricted to large cities and areas round them, called suburbs.

It is a pity that the present day engineers and architects have totally neglected this 90 to 95 p. c. of building construction and concentrated their sole attention on the remaining 5 to 10 p. c. only.

Many of such houses built some 200 or 300 years ago have still been standing in perfect

order. Hence, it is beyond question that this system has stood the test of time. There are some inherent defects in it, no doubt, but they can be easily remedied by the application of the advanced knowledge of the present day.

This does not mean that the writer is averse to, or decries the use of, cement and lime and the products of the modern science. Far from it. He has already written two books in which he has described the up-to-date methods of Building Construction. But the first hand knowledge which he recently obtained by visiting several parts of the country to study the housing conditions, has convinced him that for the average Indian, who is very poor, they are rather expensive luxuries. Again, by using local material as far possible, we help to solve partially the problem of unemployment which, so frightfully stares the country into the face. Besides, in addition to cheapness there are some special advantages which this system possesses. These have been discussed elsewhere in this book.

It is true that we want more houses immediately to relieve the overcrowding, but the point of far greater importance than that is, that we want them to be built on the most sanitary principles. It is for this reason that a long chapter on Domestic Sanitation has been added, and another on repairs and altera-

tions, in which, practical hints on improving the sanitation of the existing buildings are given.

The book does not pretend to give the reader that amount of information which would enable him to build a cottage with its help from the foundations to the roof. The latter has been sought to be done in the author's other work viz., "Modern Indian Houses and How to Build them." The purpose of the present volume is to give the reader practical hints on economy and domestic sanitation, so as to enable a layman of the middle class to secure maximum health and comfort within a minimum amount spent.

However, cheapness is not always synonymous with economy. There are primarily two factors to be considered: one, the initial cost and the other, the maintenance charges. An item which is slightly costlier in the beginning, but saves a lot for upkeep, is more economical in the long run. Again, a note of warning must be sounded against the employment of unsound, cheap material, of an inferior character, which soon deteriorates, and becomes unhealthy, or of bad workmanship, which one, in one's enthusiasm for cheapness, is tempted to overlook, or connive at. These defects tend to foster in them a sense of carelessness and untidiness. How is it possible to keep a house neat and tidy, in which the plaster of walls is continually falling off in patches, the joints in wood work

of the upper floor opening out and allowing loose earth to drop at a slight shaking; roof leaking and causing damp in floors and walls; the yawning joints in wood-work of doors, windows and cupboards etc. giving room for dust to collect, and bugs and other vermin to breed; drains choking every now and then and causing emanations of foul gases etc.? Even the tidiest housewife would soon be disheartened and become dull to the sense of dirt and uncleanliness. The spirit of tidiness once gone leads to untidiness in other things such as dress and personal hygiene, and makes the house dreary, filthy, and squalid, and no longer a pleasant, cheerful and sweet home.

If a pleasant looking, comely cottage, planned for comfort, and sound in construction, howsoever humble, is provided, the occupants instinctively take a lively interest in keeping it neat and tidy. Once they catch this spirit in right earnest, it is easy and inexpensive to render it more pleasant and attractive by little things such as a wash of cheap distemper, planting a few roses here, a bed of seasonal flowers there, a few flower pots at another place, and so on, and thus gradually develope an artistic taste for decoration.

Just imagine a cheerful wife and gay children taking delight in watering flower plants in the evening, and looking with pride at the

flowers grown by their labour! Could there be a better recreation for them? Could there be a more refreshing sight than this to the humble clerk or the school-master returning home, exhausted after the day's hard labour?

In conclusion, the writer craves indulgence of the reader for appreciation of his humble but sincere attempt for the amelioration of the housing conditions of his poor countrymen, fully conscious as he is, of the many defects and imperfections left in the book.

# Cheap and Healthy Homes for the Middle Classes of India.

## MATERIALS.

The question of materials is of the greatest importance in building construction, because upon it depends, to a very large extent, its economic success. Materials which have to be transported from long distances are costly. Some times the cost of transport is twice or three times that of the materials themselves at the site of their production. Restrictions imposed by heavy tolls on roads, customs charges and freight charges on Railways etc. tend to check the transport and enhance its cost. Hence, for economic success of a building, materials which have to be transported from long distances, must be avoided as far as possible. This is tantamount to saying, that local materials available must first be explored, and ways and means must be devised for utilising them fully, so as to eliminate, or at least to reduce to a minimum, the unnecessary cost of transport.

Again, materials always look well in the place where they are naturally found and very

unbecoming, away from it. Local materials are easily adjustible to their natural surroundings; they tend to retain their tradition, and maintain the architectural aspect of the place.

Amongst the materials required for building those useful for walling form the main bulk. Next come, timber, mortar, roofing materials, ironmongery etc. in their descending order of cost in the estimate.

Walls are most commonly constructed of either stone or burnt brick or a combination of both. For cheap houses sun-dried mud brick or mud also is often used- a point to which we shall come later on. When a choice between stone or burnt brick is to be made, a layman is often very much puzzled as to which of the two, is to be preferred. We shall, therefore briefly discuss the merits and demerits of each.

## BRICK VERSUS STONE.

From the fact that we see several stone buildings exposed to elements, still surviving the vicissitudes of ages, we are perfectly justified in saying that stone is more durable than brick and that it is capable of resisting the atmospheric and other external influences to a far greater extent than brick. But at the same time, we must not forget the fact that even the most optimistic person never thinks or imagines

that his house would last for several hundred years. He would be content, if it lasts only for a hundred or hundred and fifty years. And we actually see brick houses built some three hundred years ago, still standing in perfect condition in defiance of the fury of the elements. Hence, we can justly say that for our practical purposes a brick house is as durable as a stone house.

2. From the point of view of protection from thieves and house breakers a brick-in-mortar wall is as strong as, if not stronger than, a stone wall. This is so because, to make an opening into a stone wall it is comparatively easy to rake out joints on all sides of a stone and to pull it out whole, but the adhesion of brick to mortar ( good of course ), is so great that in order to pierce a hole into a brick wall, small pieces of brick have to be chipped off, which cannot be done without a considerable noise and severe shaking of the whole wall.

3. In respect of ornamental or plaster work, brick possesses an undoubted advantage over stone. Because in the first place, plaster sticks to brick more firmly than to stone and secondly brick, by its very soft nature, allows its being roughly cut with an axe to the approximate shape, which can then be improved upon with plaster and be given the desired smoothness for decorative effect. With stone

this is not possible, or at least is very difficult and expensive.

4. Brick having a right angled square shape is more suitable and cheap for corners. Even for jambs of doors or other work involving an acute or obtuse angle, the very fact that it can be easily cut, makes it very convenient. Its size and handy weight make it very easy to manipulate.

5. Brick work requires a fixed quantity of mortar and on account of its flat, square shape, there is a less chance of its remaining hollow at the hands of bad workmen. In stone work, there are far greater chances, of both waste of mortar occurring in the filling of the hearting, and also hollows being left unfilled if the masons are careless.

6. A still greater advantage which brick work possesses over stone work is, that walls of from 3 in. thickness with brick on edge, or 4½ in. with brick laid flat, or 9 in., 14 in., or any width above this, can be easily built. The least thickness of a stone wall, on the other hand, is 15 in., in which case also it is not regarded strong enough for supporting walls of the upper storey, because unless a stone wall is at least 18 in. thick, on account of the comparatively big and irregular size of the individual stone, there is not sufficient

bond in it. A brick wall only 14 in. thick on the other hand, can support walls of the upper floor and an additional advantage is that, for the same quantity of brickwork, rooms are made 4 in. longer and 4 in. wider than those with 18 in. stone walls.

7. Another advantage brick possesses over stone, particularly in tropical countries is, that brick does not absorb so much heat as stone does.

From the foregoing discussion it will be seen that in point of durability and strength, brickwork is, for all practical purposes, as strong as stonework and is certainly superior to it in several other respects.

However, the quality of bricks manufactured in India, except perhaps in Sind and some other places, is very poor. Even the Bilimoria or Calicut bricks which are highly praised, do not stand comparison with bricks of English manufacture. If the quality improves in future, there are bright prospects for brick industry in India.

The disadvantages of brickwork are that it absorbs moisture and is therefore unhealthy particularly in damp situations; that so long as the quality is not satisfactory it requires plastering on the outside. The plaster not only increases the cost but its repairs and the

renewal of colour on it, have to be constantly attended to at a considerable recurring expense. Even if the colour fades, or the surface is disfigured by atmospheric influences, it presents a shabby appearance. A third disadvantage is, that though it absorbs less heat than stone, having once absorbed it, it parts with it but very slowly. Hence, brick walls exposed to sun take a longer time to cool down during night.

As regards costs, very often the apparently higher rate of brick work leads one to imagine that it is more costly than stonework; but a little consideration will show that where stone walls 18 in. thick are required, brick walls only 14 in. thick do very well and therefore, within the same volume of masonry, a longer wall can be constructed in brick work than that in stone work. Hence the rate has to be reduced to $\frac{14}{18}$ for comparison with that of stone work. An example will make this more clear; the rate for brick work in lime at Poona is Rs. 50/- and that for 2nd class coursed rubble stone masonry is Rs. 40/-. Now the rate of Rs. 50/- if reduced to $\frac{14}{18}$, because brickwall is 14 in. thick, while stone wall must be 18 in. thick, $50 \times \frac{14}{18} =$ 39/- Rs. which is, in reality, less than the rate for stone work by a rupee. Hence, in this particular instance brick work is cheapar.

In order to ascertain whether brick-work or stonework is cheaper at a particular

place the following rough rule may be remembered.

When the rate per 1000 bricks of standard size ( $9'' \times 4\frac{3}{8}'' \times 2\frac{1}{2}''$ ) is $2\frac{1}{2}$ times the rate per 100 cft. of good stone rubble, both brickwork and stonework cost approximately the same. To illustrate this, let us suppose that at a certain place bricks cost Rs. 20/- per 1000 and good rubble Rs. 7/- per 100 cft. Which masonry is cheaper ? Now, $7 \times 2\frac{1}{2} = 17\frac{1}{2}$. this is less than Rs. 20/-. Hence at this particular place, stone masonry would be cheaper.

It is worth mentioning here that the thicker the brick, the better it is, from the point of view of economy. Because there being less number of joints, less mortar is consumed and there is also a saving in labour.

Regarding other materials which are locally available and used for walling such as wattle and daub, earth, bamboos and planks of wood etc. they will be discussed later on under "Walls".

Next in order of importance comes timber. Teak is undoubtedly the best, but though grown in forest in almost all parts of India, it is often costly on account of long distances from which it has to be transported. In such places, some of the local variety of timbers would be found to give perfect satisfaction, if used in positions in which they have been proved, by local usage,

to give best results. For example, Ain* (Marathi) is a strong, durable variety of timber but is unsuitable for use in exposed positions, where it cracks by the heat of the sun. Otherwise, it is an excellent timber, as it keeps well in damp situations—even in water, and is not attacked by white ants. Similarly Neem † (Hindi) is excellent in all positions except moist or damp ones in which it warps and bends. Hence, it is good for door frames, posts, beams, lintels etc. but not for rafters, or panels of doors and windows in exposed walls.

There are a number of strong and durable varieties of timber in India but many of them are attacked by white ants. Such varieties should be used only in such positions as would allow them to remain exposed to view and be easily replaced when necessary, without requiring any considerable part of the building to be dismantled; e. g. shutters of doors, windows, shelves, posts (not buried in walls), furniture etc.

Even more important than the white ant is the other enemy of timber to be most feared. It is "Dry Rot". It is a kind of fungus, which once established spreads over and eats into the

---

* (1) Equivalents of Ain in other vernaculars are :—Matti (Kanarese); Sagada (Gujerati).

† (2) Equivalents of Neem in other vernaculars are :—Nimb (Marathi); Vepa (Tel.); Vepum (Tam.); Bevu (Kan.).

entire piece with marvellous rapidity. It generally commences in sap wood. A scantling apparently sound may have been entirely hollowed out inside by dry rot. Its presence can be detected by gently tapping on the timber, when it sounds hollow, which is an indication of the fibres having been reduced to powder. The cause of its appearance is damp and want of ventilation. It is unfrequently due to the timber being insufficiently seasoned. It is found mostly in unventilated wooden floors damp cellars, in timbers buried in walls such as, ends of beams, wall plates, door frames etc. Once it attacks timber there is no remedy but to remove the whole of it, with all the traces of the fungus. Application of one or two coats of hot coal-tar is an effectual remedy. But the timber must be previously thoroughly dry.

A suggestion to laymen, while using timber will not be out of place here. It is this: when a scantling is used for resisting a stress coming at right angles to its length, as for instance, like a beam or rafter, its stiffness varies as the product of its breadth and the *cube* of its depth which is indicated by the formula :—

$$S \propto B\,D^3.$$

*i. e.* Stiffness varies as breadth × cube of depth.

Therefore if a scanting of more breadth is used, there is some gain in strength no doubt, but it does not add to its stiffness or resistance to bending; but if the depth is increased even slightly there is a considerable difference in respect of stiffness. For example, see the three beams :—

| Beams | sectional areas and costs vary as | resistance to bending varies as |
|---|---|---|
| (i) $4''^{(b)} \times 5''^{(d)}$ | 20 | 500 |
| (ii) $4''^{(b)} \times 6''^{(d)}$ | 24 | 864 |
| (iii) $3''^{(b)} \times 7''^{(d)}$, | 21 | 1089 |

This shows that though the 2nd is the costliest of the three, it is nearly 20 p. c. less strong than the third, and the third beam which costs almost the same as the first is more than twice as strong. Of course, if the breadth is too small in proportion to the length the beam buckles side ways.

## MORTAR. *

It would be out of place here to explain how mortar is prepared, what constitutes a

* The word 'Mortar' has been used in this book to convey the sense of any thing that binds together. Hence it is not necessarily of lime; it may contain lime, cement, or mud and therefore may be called lime mortar, cement mortar, or mud mortar.

good mortar, or how a layman can apply a rough test for distinguishing it from a bad mortar. All this has been done in great detail, especially from a layman's point of view, in the author's book "Modern Indian Houses and How to Build them." It is only the economical aspect of all materials including mortar that is sought to be discussed here.

There are two varieties of lime used in the preparation of mortars. One, fat lime and the other hydraulic lime. Fat lime is one, which when slaked or treated with water makes a hissing noise, steams and bubbles up, giving out considerable heat, and increases in bulk. It is good for plaster or white washing. It derives all its strength by chemical action with carbonic acid gas, which it absorbs from the atmosphere. Hence, excepting in positions like that of plaster, where it freely gets carbonic acid gas, it lacks in strength. It does not set in water and keeping it moist does not help it in gaining strength.

Hydraulic lime, on the other hand, slakes but slowly and while doing so, does not give out so much heat, nor increase so much in bulk. It sets in water and moisture helps it in hardening. It possesses considerable strength.

Of course, hydraulic lime is the best as a building material. But it is not locally available every where. Still, one need not be sorry

for it and try to transport it from long distances; because in the first place, there is very little transverse stress in ordinary buildings. Practically the whole stress is of the compressive nature, that is, one coming vertically down. Hence, mortar of strong hydraulic lime is not necessarily required for ordinary buildings. Secondly, if more strength is desired the deficiency of it in the fat lime can be made good by grinding *surkhi,* or powdered burnt clay, with it. The latter also increases its bulk.

The strength of the fat lime mortar is slightly improved by mixing it with a slightly greater quantity of sand than ordinarily required. Because sand tends to make it a little porous and allows it a greater chance of absorbing carbonic acid gas, from the air, upon which its strength depends.

If the fat lime is of a pure, unadulterated quality, sand to the extent of 2½ to 3 times its bulk, could be safely mixed with it to make the mortar suitable for domestic buildings. Where sand is not available at a cheap rate because of its transport from a long distance, *surkhi* may be used in its place either partly or wholly.

Lime mortar, after all, is an expensive luxury, which middle and lower class people cannot afford. I have already remarked above, domestic buildings have very little transverse stress coming on their walls. Perhaps the

only transverse stress is that of wind pressing at right angles to their face, but as such buildings are not very high and of any considerable length unsupported by cross walls, that stress is negligible. Hence, for all practical purposes, there is little justification for this expensive luxury. All that is necessary is, to make the external faces of walls reasonably water-tight, which is, invariably or at least in the majority of cases, done in India by means of either oil painting or lime plastering even in the case of walls in which lime mortar has been used.

This fact appears to have been fully recognised and advantage taken of it by our wise forefathers. Because, if we examine the old domestic buildings—even those belonging to the nobility and richer classes of those days, standing in defiance of the meteorological changes of the past several hundred years, we shall see them invariably built in mud mortar. They have used lime mortar only in such places, like terraced roofs, parapets, bath rooms, drains etc.–places where water-tightness was required. Lime mortar is found to have been used in walls of palaces, forts and some of the public buildings, such as temples and mosques. Even in our own days to-day practically cent per cent of the houses in villages and over 90 per cent of those in towns even of

recent construction are of walls with mud mortar, with some special treatment for exposed walls surfaces. Even in large cities like Bombay, Calcutta, Madras, and others many old houses counted by hundreds will be still found to be of a similar construction. It is only very recently, perhaps under the compulsion of Municipal bye-laws, that new houses erected on old sites in large cities and new bungalows built in suburbs, that have walls built with lime mortar, and on extensions on the outskirts of large towns, cottages have recently been springing up after this fashion (though there is no compulsion of Municipal authorities), in blind imitation of the bungalows of their "refined" city brethren. It is a pity that none of the present day engineers and architects takes interest in reviving or rather preserving this time-honoured economical method of building construction with the direful result that we are fast foregetting it and it is becoming a fashion of the day to build everything in lime mortar though majority of our people cannot afford it.

The mortar ordinarily used in buildings is in most cases of fat or mostly fat lime. Again, if the sand mixed in it contains earthy matter, or if the mortar is not ground well—things which are of very common occurrence—resultant lime mortar is no better than the specially

prepared mud mortar, and yet its cost ranges from Rs. 20 to Rs. 30 per 100 cft!

All earths are not suitable for preparing mud mortar. The best sort is the earth* which is more or less impervious to water, that is, is the least absorbent and which, therefore, allows water coming in contact with it, to flow away without allowing it to penetrate itself beyond the skin layer of quarter of an inch at the most. Still, it must possess freedom from both excessive swelling when mixed with water and excessive shrinking when getting dry again. Otherwise, it will form cracks while drying. Earths containing too much of clay are bad in this respect. They can be improved by an admixture of sand in it, the proportion of which can be determined by actual experiment.

The ideal earth for this purpose is found in and around towns and villages, where the earth, perhaps by the constant treading of men and cattle, and by the action of the manure usually produced in homesteads, attains this property of imperviousness to water to a remarkable degree. It is generally whitish in colour and therefore goes under the name "white-earth". Mixed with cowdung, it is

* This subject has been treated in greater detail further on under Earth walls and in appendix.

used as a plaster by village people for annual repairs to mud walls and leeping the wall surface both inside and outside. It is, in fact, the poor man's whiting for giving an annual wash to the walls of domestic buildings. On account of its remarkable property of imperviousness to water it is successfully used on the top of terraced roofs. A 6 in. layer of this earth on a flat wooden ceiling is sufficient to afford an excellent protection from rains. The next best earth is, what is called 'Chopan' soil in the Deccan. This is brown, grey, or yellow in colour and its main characteristic is, that it is non-absorbent and hard—so hard and compact indeed, that vegetation does not thrive in it, as it does not allow its roots to penetrate its surface, and its compactness prevents their æration.

In many places this white earth is found to be not satisfactory in point of imperviousness to water. This is due to the preponderence of calcium (lime) and mostly potassium salts, (knitre) which absorb moisture from the air. Again, there are places where the white earth is, to all practical purposes, impervious, to start with, but in the course of a few years it loses this property and shows, day by day, an increasing tendency to absorb moisture from the air and become damp. The earth near the ground surface in walls showing such damp patches

loses coherence and comes off in powder at a slight touch. Hence, people prefer to transport special earth popularly but wrongly called "Khari Mitti", which is, in fact, chopan earth, from long distances, to rather using this local white earth. This Khari Mitti, too, deteriorates within a few years.

The remedy for this evil is to leach or wash out the salts from such earths. The easiest and cheapest way of doing this is given below.

Spread about a six in. layer of straw, hay, or any such material as would facilitate drainage. Make on the top of this, a heap of the screened loose earth, say about 2 ft. in height. Make a hollow on the top of the heap and fill it with water up to the brim. As the water sinks down, add more and continue this for a number of days till the water level does not appreciably sink down. It will be found that most of the salts will have gone out with the water which percolated through the bed of straw, leaving only impervious earth in the heap.

It was the old practice to keep such heaps for "Souring" for a month or more, before they were broken up and mixed with water for forming mud mortar especially for plaster. The whole secret of making the earth hard and impervious to water lay in this process of "Souring", which, in fact, was nothing but one of leaching salts.

## MAKING ARTIFICIAL WHITE EARTH.

In places where white earth of the best quality, or even that of inferior quality impregnated with salts as described above, is not available, any earth can be artificially rendered impervious by the following device.

The process involved is just the opposite of what is done for improving heavy lands and making them suitable for agriculture. For this, dig out earth and remove the top layer of about 9 in. of it, which is full of decaying matter and roots of vegetation, technically called "humus". Excavate the earth from the lower stratum and put it into a shallow heap to dry. Sift it through a screen of about $\frac{3}{4}$ in. mesh to exclude stones and especially nodules of lime kankar. Then mix with it any *sodium* salt such as, salt deposit from near the sea-shore, surface earth from patches of land, spoilt by the rise of underground water-table, called *Reh* or *usar* lands. The distinguishing feature of the latter is, that it is always found in powder of brown or grey colour and tastes salt and bites if applied to the tip of the tongue. Failing to obtain these within a reasonable distance, mix impure variety of common salt, offered by Government at a very cheap rate for manurial purposes, and failing to get even this, use sea water. The exact proportion of salt required depends upon the nature of the earth proposed

to be treated and the degree of concentration of the salt in the stuff. This may be determined by actual experiments, by trial and error, and that proportion, which gives the best result in the individual case, may be finally adopted.

The salt mixed in the earth should be leached out by making heaps on a bed of straw and filling water in the hollows on their top as described above. The more perfectly the salts are leached out the more impermeable would the earth become.* The most satisfactory way of doing this is to stir the mixture thoroughly in water in a masonry or iron tank, allow the earth to precipitate, and remove the water from the top. This may be repeated once or twice again. But this is possible only when the quantity of earth to be dealt with, is small, otherwise, the cost becomes prohibitive. Hence, the above simple and more practical method is suggested.

---

* In order to determine whether a certain soil is "sodiumised" or made impervious, the following experiment may be made :—

Take a glass tube open at both ends, close one of the ends with a piece of muslin or any thin cloth and fill it with the sample to be tested. Place it vertically in a basin containing pure water, first, with the muslin end down, for some definite interval of time, say, one hour, and note the rise of water by capillarity. Then repeat the same experiment with a fresh sample in the tube, this time not in pure water, but in the same quantity of water in which some common salt is dissolved, for the same interval of time. If the sample is 'sodiumised' or made impervious, it will be found that the rise of water in the tube in the case of salt water is considerably higher than that in the case of pure water. For scientific explanation of this please see the appendix.

In short, in order to prepare 'white' or impervious earth artificially from any earth available, add any variety of *sodium* salt, whichever is cheaply available even in an impure state, such as, a deposit of common edible salt ( $N_aC_l$ ), washing soda ( $N_a2CO_3$ ), glauber's salt ( $N_a2\ SO_4$ ) etc. and then *wash the salt out.*

This is not the place to enter into the chemistry of the soils and explain the exact chemical actions involved. But for the satisfaction of those who want to go more into the details a note has been given in the Appendix.

This impervious earth, either natural or artificial, as it is compact and does not hold water, is generally free from shrinkage when wet, and from contraction when dry again, and therefore, the cracks if formed at all in it, are only superficial. Still, it can be improved even in that respect by mixing either sand or some other soil with it. Thus, if clayey earth is mixed with loamy soil the resultant mixture is quite good. The object to be aimed at is, that there should be sufficient clayey material to give the mortar hardness when dry, and there should be sufficient sand or sandy material to prevent undue shrinkage when drying.

# FOUNDATION.

The walls of a house must be built on a sufficiently solid and substantial foundation to prevent them from sinking or settling into the ground, which usually causes them to crack. They have also to be formed of sufficient thickness to secure a due amount of stability and afford protection from the heat of the sun.

It is quite true that it is impossible to rectify weakness once allowed in the foundations when the walls are raised, and therefore, one should always err on the safe side by spending a little extra money to ensure the soundness of foundations. But it is observed that in the majority of houses of the middle class people in India, which are comparatively quite light buildings, much money is unnecessarily wasted in excessive depths. It is an erroneous impression that an increase in the depth of foundations always increases the stability of walls.

The ground surface, unless it consists of rock or hard murum, is generally loose and full of roots of vegetation upto a depth of, say, about 9 in. If we excavate deeper than that depth, we find that the soil grows more and more compact. But there is a limit, of the original virgin soil, which, when once reached the compact-

ness increases but very slowly, if at all, if the strata are uniform. Every soil has a certain amount of bearing power, and if the intensity of the load put on the soil is within the limit of that power, it does not sink.

If the compactness remains the same and if we still go deeper for foundations, what we do is, to add more load on the foundations and thus in seeking to strengthen, we actually weaken them.

There is some specific object in digging to a-depth of about 3 ft. in the soil: It is generally held that the effects of atmospheric and other influences do not reach beyond that depth. That is to say, the foundations in soil, if carried to this depth, are not affected by rain-water soaking into the soil, by acids dissolved in the atmosphere causing it to decompose, and by rain water flowing on the surface eroding it. A depth of three feet is generally regarded sufficient to resist all these influences.

Hence, unless it is a black cotton soil which requires a special treatment, it is not advisable, in the interest of economy, to go more than 3 ft. below the ground surface and as a general rule, even in the case of black cotton soil or of the made up ground of recent filling, it is uneconomical to excavate below 6 ft., if we do not strike murum, one or the other, of the remedies mentioned below, which-

soever would suit the particular circumstances will be found to be cheap and effective. These are :—(1) To lay one or two layers of boulders at the bottom of trenches, to flood them with water, and to ram them hard, so as to prepare an unsinkable base for the walls to build upon.

(2) To fill the lowest two feet of the foundation trenches with river sand slightly moistened and packed well, upon which the footings of the walls may be built. The word "sand foundations" might sound rather queer to a layman who may be led to suppose that he is proposing "to build on the sand" but in reality sand is practically incompressible and hence, if the sides of the trenches are not likely to yield by horizontal pressure conveyed by it, sand filling forms an excellent method of strengthening foundations under certain favourable circumstances.

(3) Excavating pits at intervals down to the murum, filling them with lime concrete and connecting them all together by means of arches of the same material, a little below the ground surface. This is a very simple and cheap method.

(4) Widening the foundation trenches so as to distribute the load on a greater area and laying lime concrete at least two ft. in depth above it. The latter serves as a beam and helps in equalising the pressure above.

These and few other simple devices have been described in detail in the writer's "Modern Indian Houses and How to Build them." In order to avoid repetition of the same, only a casual reference to them has been made here.

If the ground is of a doubtful nature trial pits should be excavated and the soil carefully examined. Black cotton soil swells when wet and shrinks very much again when dry, and thus forms a very treacherous foundation. The only device which has so far been found successful in resisting its effects is to construct a reinforced cement concrete ( R. C. C. ) beam 4 to 6 inches thick all round, of the full width of the walls at the plinth level. If the soil is very deep, another beam may be similarly laid at the level of the top of windows and doors which serves also as lintels. Detailed information about this also, has been given in the book mentioned above.

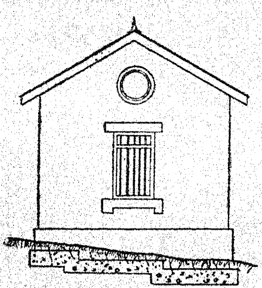


Fig. 1

When the ground is sloping steeply it is possible to effect economy by stepping the foundations as shown in the sketch fig. No. 1. Care should be taken to make the lower layer sufficiently overlap the upper, otherwise a weak spot may be formed at the junction of the step.

## FILLING IN THE FOUNDATIONS.

If the soil is firm and the structure to be raised is a light, ground floor building only, it is not necessary to lay lime concrete in the foundation trenches. All that is necessary is to pack stones close together in mud mixed with a certain proportion of sand or soft murum. The stones should be as large as possible, laid on their flat surface and the intermediate spaces should be filled with chips and smaller stones packed in mud by means of a hammer. Even boulders may be used as they are found in natural state i. e. even without breaking them.

It is desirable to use stone up to the plinth, but where it is scarce e. g. in the deltaic tract of Sind, over-burnt or well-burnt bricks should be used.

## HINTS FOR ECONOMY.

If the soil is not sufficiently compact or if the building is to have several storeys and therefore lime concrete has to be used, the following hints may be adopted for economy:—

For lime concrete, a proportion of 2 to 2½ parts stone metal to 1 of mortar is generally used. But if the stone metal is graded that is, if all the sizes from 1½in. to ¼in. are used, by mixing gravel and sand in certain proportions, the quantity of the lime mortar can safely be reduced. By adopting the usual proportion of

2 to 2½ of metal to 1 of lime mortar what we do is, to fill all the voids of the metal by means of the mortar. By using the aggregate of varying sizes, we fill the voids in the metal by gravel, the voids in the gravel, by sand, and those in sand, by mortar and thus ensure even greater compactness by using less mortar.

2. It is possible to reduce the quantity of metal in the concrete and effect economy by using a fair number of big stones in the body of the concrete. This also adds to the strength of the concrete. The process of doing this properly is described below :—

(a) First lay a 4 to 6 inches layer of concrete and ram it well.

(b) On the top of this, lay some 2 inches of concrete and before it is rammed, place big stones with their flat or broad surfaces at the bottom, taking care that they are thoroughly embedded in the concrete below.

(c) The stones should not touch each other. It is advisable to leave sufficient spaces between them for the facility of packing concrete all round them. As the concrete is laid in between and round the stones it should be rammed by a wooden handle or a pointed iron rammer.

(d) The top should be finished with a 3 inch layer of concrete and the whole thing should be rammed well.

This sort of concrete is called "Plum concrete". It is not only cheaper than ordinary concrete but if properly made, is also stronger.

3. In most cases lime concrete is cheaper than rubble masonry. Besides, the small pieces of stone in concrete ensure greater compactness when rammed well than the rubble masonry which is likely to remain hollow at the hands of a careless mason. Hence, it is both economical and sound to bring the concrete layer up to 6 in. below the ground surface in the case of external walls and up to ground level for internal walls. In the case of external walls it is necessary to keep the concrete at least 6 in. below ground to prevent its being exposed to view, if by chance the ground is scoured or denuded.

4. If the rate of concrete is considerably less than that of uncoursed rubble masonry, laying concrete even up to the plinth level in the case of internal walls would save a lot of money. It is necessary for this to fill in earth up to plinth first, then excavate trenches in it just above the concrete already laid below and fill concrete in them. If necessary the walls should be provisionally lined with stones to facilitate ramming of concrete. They can be afterwards removed and used elsewhere.

## PLINTH.

It is not prudent to curtail the height of the plinth for the sake of economy. The deter-

mination of the exact height depends upon several considerations. In damp situations or marshy sites the higher it is, the better. If the soil is of non-absorbent nature and the site is sloping sufficiently, so that rainwater is easily drained away from the building, the plinth need not be very high. 2 to 3 ft. should generally be sufficient for ordinary conditions. In no case should it be less than 1½ ft.

It is customary to provide some sort of coping, at the plinth level, either of fine dressed champhered stone, or cement concrete 4 in. to 6 in. thick all round the building. Its purpose, viz. to allow the rainwater from the face of the walls to flow away from the masonry of the foundation is, in most cases, not properly served as a drip moulding is not provided. Hence, it serves no purpose beyond that of a decorative effect. It may therefore be safely dispensed with in the interests of economy.

Money is often unnecessary wasted even in villages, where good stone is available, in building plinth of very finely dressed large stones. This practice on the part of the middle and lower classes is to be severely condemned as it does not add to the strength of the building. This waste, if stopped, can be utilised elsewhere in items which contribute to increase convenience and comfort.

Very often the site is sloping steeply. If the slope is in the longitudinal direction, that is, if there is a difference of levels between the front and the rear of the house, there are two ways possible (1) To design the floors of different rooms at different levels according to the slope of the ground and (2) To keep the floor level of the entire house the same, which, of course, must be a little above the ground surface on the higher side, and to construct a cellar below the floor on the lower most side. If the floors are kept at different levels, there is some saving in the plinth masonry no doubt, but as the roof also cannot possibly be constructed at correspondingly different levels the ultimate saving is not worth consideration.

## CELLAR.

A well ventilated and lighted, dry cellar is an advantage particularly in small cottages in the tropical countries. Many and varied are the uses of a cellar. Firstly, it affords an absolute protection to the room above it, from the evils arising from damp ground. Secondly, it affords an excellent place for storing certain articles which keep well only in cool places of equable temperature, away from strong light. Thirdly, though even in best situations its use as a bed room is not commendable, it certainly provides a cool sitting room in hot climes during part of the day when heat is unbearable.

In such places a cellar is a necessary adjunct from the point of view of comfort.

Many people, not accustomed to the use of these cellars or '*Tahkhanas*' as they are called in Northern India, upon first entering, experience, a pleasant sensation of coolness and comfort on account of a considerably lower temperature in these subterranean chambers than that outside, but in a few moments a feeling of disagreeable stuffiness or oppressiveness is felt by them and a free perspiration is caused. This is due to two reasons: one is, that lot of water vapour caused by the damp is present and secondly the air in the cellar is stagnant. If, therefore, adequate means are provided for frequently changing the air, this source of discomfort no longer remains.

Still, it is neither practicable nor desirable to construct a cellar in every house though it costs only about 60% of that of the ordinarily built-up floor area. It is a common belief that rocky or murumy strata are best suited for construction of a cellar. But in reality, it is quite the opposite. Rock and other hard strata cost a good deal for excavation and cannot easily be kept dry on account of the joints or fissures in them. It is a different matter with soils. The more clayey the soil, the better it is, from a point of view of impermeability with respect to water.

The most economical and efficient method of constructing cellars is described below:—

Do not excavate below ground for cellar space first, and build walls on sides afterwards, as is usually done. But excavate foundation trenches as usual, to 6 inches below the proper level of the cellar, and fill them up with concrete right up to 6 inches below ground level under exposed walls, and even upto ground level under inner walls. If the soil is sandy or murumy and trouble from percolation of water through it is feared, the outer 6 to 9 inches width may be filled with cement concrete (one of cement, two of sand and four of stone metal) and the remaining inner width, with rather a rich lime concrete, both to be laid side by side in layers of 6 inches and rammed well as shown in Fig. 2.

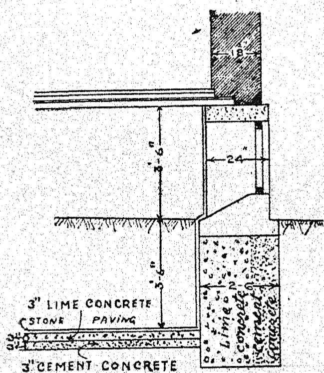


Fig. 2

On the top of the concrete so laid, walls should be constructed with face masonry of stone or brick in mortar consisting of 4 parts of sand, 1 of cement, and ½ of cream of lime, and inside masonry as usual but slightly in richer lime mortar. This should be kept well

watered for at least one week. Then the earth or whatever other stuff there may be in the cellar portion, should be excavated to 6 inches below the required depth for obtaining the cellar space. A layer of 6 inches of cement concrete or at least 3 inches of cement concrete at *bottom* and 3 inches of lime concrete above it, may be placed for flooring of the cellar and the surface paved with slabs if desired. When the ceiling is constructed the inner sides of the concrete wall should be washed and dressed, where necessary, and plastered with a mixture of 4 parts of sand, one of cement, and ½ of cream of lime with a final thin coat of fine sand and cement in equal proportions. The joints of the face masonry should be pointed with cement as usual. The floor should slope towards a small pit or sump. The cellars constructed in this manner may be depended upon to be watertight.

For light and ventilation a sufficient number of windows should be provided with their sills at least 9 inches above the ground surface. Shutters of very fine wire mesh are required to keep out vermin. The height of the ceiling above floor should be at least 7 ft.

## DAMP AND HOW TO PREVENT IT.

Damp is one of the greatest enemies of health. It works out greatest mischief especially when it is present in close, dark rooms, with inadequate means of renewing the air. Even in rooms with free circulation of air, damp alone is a source of danger; it interferes with the natural evaporation from the skin surface of the human body; it carries the impurities in the air; and it maintains a low temperature. All these factors combined together, make the place unhealthy even though actual disease germs may not be present. But when the rooms are close and dark and free circulation of air is wanting, the danger is enormously increased. Damp causes organic matter to decompose, and the latter gives out poisonous gases, which diffuse into this air full of water vapour. The latter forms a breeding place for microbes of diseases and when inhaled they get a direct entrance into the human system to work mischief. This has a very deleterious effect upon infants and women who have to keep indoors for the most part of the day.

Malaria, neuralgia, acute and chronic rheumatism are the direct results. These diseases suck the life blood and eat into the

very vitality. The heavy toll of death on human life especially amongst infants and females by anaemia and consumption is the direct consequence of the presence of damp in ill-lighted and ill-ventilated, stuffy houses.

In spite of this, our people have lost a sense of fear about it, because, they are so familiar with it. It is the commonest thing in villages, crowded towns, and in old fashioned houses in cities with the mud walls. The writer has specially visited a number of houses which Dame Superstition had denounced as haunted by evil spirits owing to the successive deaths which had occurred in them, and he invariably found them to have been ill-lighted, ill-ventilated and affected by damp to such an extent that it was most trying to stand there even for a few seconds breathing in the horribly stinking exhalations emanating from the mouldy surface of the walls and floors.

Is there no remedy? Is it not possible to fight and stamp out this diabolical evil of damp? Certainly it is. Only, you must have a strong will and a firm determination to fight the evil. In this chapter I propose to discuss how damp can be prevented and later on under 'Sanitation' point out remedies to eradicate it, where already existing.

There are many sources of damp, but (1) the damp rising from the soil (2) Damp

descending from the roof into walls and (3) moisture driven by piercing winds through the external walls are important ones.

Damp rises from the ground in two ways. One, through the foundations and the other through adjacent ground surface touching or coming into contact with the material, of which the walls are composed. The moisture absorbed by the wall from the base is comparatively very little. That entering the wall from the earth against the sides is considerable. The exact quantity depends upon the wetness of the side earth and the absorbing capacity of the materials of the wall.

One remedy to prevent this damp rising up the walls is to keep the plinth level higher than the ground surface surrounding it. Still, the moisture absorbed by the lower portion of the wall rises up by capillary attraction several feet and shows itself by direct evidence of irregular stained patches, or mouldy surface.

Very often houses are built close together and the narrow space between them gets filled with earth or other debris which go on accumulating and its top rises higher than the plinth level. The moisture from this is absorbed by the walls even though the plinth may have been kept high above the natural ground surface all round, when first built.

Another cause of damp rising from the ground is the slop water from sinks in the kitchen and especially from bath rooms which, in most cases, is allowed to be absorbed in the ground close to the house. The obvious remedy for the latter is to convey it through a pipe or an open channel of a non-absorbent material to a distance of 15 or 20 ft. away from the house into a cement lined under-ground cistern, lift, and distribute it daily over a large open ground for evaporation by the sun. Small pails may be kept below pipes from the sink in the kitchen which should be similarly emptied every day. This will be treated in detail under 'Sanitation.'

For preventing damp rising from the ground, there are several remedies but the one which is cheap and efficient is to cut off the connection of the lower portion of the walls with the upper by interposing a course of some damp-proof material, a little above the ground level—preferably just below the plinth. Different materials might be found suitable at different places. Hence a few alternative suggestions are made here.

(1) Shahabad or other similar slabs of the full width of the walls laid in cement mortar all round. They should be at least 1½ in thick—and very carefully evenly embedded to preclude the possibility of being broken.

(2) About $\frac{3}{4}$ to 1 in. thick course of hot asphalt laid all round.

(3) A 3 inch course of cement concrete of the full width of walls.

(4) Two or three layers of slate laid in cement.

(5) Sheet lead.

(6) A layer of glazed stone-ware bricks.

(7) A $\frac{3}{4}$ inch layer of cement concrete with coal tar.

The last is very cheap and most suited for cottage building and is therefore recommended. A $\frac{3}{4}$ inch layer of cement concrete, (1 of cement, 2 of sand and 4 of gravel) should be laid and kept moist for a day. The next morning hot coal tar should be poured over it to form a uniform layer of $\frac{1}{4}$ inch thick. Sand should be freely sprinkled over it, a day allowed to pass, the extra loose sand should be removed and then wall work commenced. This is not only damp proof, but is also proof against white ants.

For preventing damp rising from the floor, if the latter is of murum or similar absorbent material, the best course is to spread a layer 6 in. thick, of shingle of varying sizes small and big, spread a little murum, say, about 2 inches thick above it, and on the top of it lay lime concrete 3 inches thick. Even if murum or mud

floor is constructed instead of one of concrete, it remains dry.

The damp descending from the top of walls through leaky roofs can be prevented by constructing a leak-proof roof. It is comparatively an easy matter to construct a water-proof pitched or sloping roof, but where flat roofs are constructed parapets have necessarily to be built. These obstruct a free flow of water and cause it to soak through cracks into walls below. Again, very often parapets are built at the ends of sloping roofs both for decorative effect and for carrying all rain water through down pipes, which, if otherwise allowed to drop from a height of storeyed building, would scour out the road or ground surface. Under such circumstances if special precautions are not taken, there is every possibility of damp soaking into the wall through cracks in the surface. These problems are discussed later on under 'Roofing'.

Remedies for preventing moisture being forced by high winds through walls are discussed under 'Walls' to suit the various materials of which walls are composed.

Another source of damp is the use of materials of absorbent nature employed in building construction; e. g. porous bricks. Some bricks would absorb their own weight of water. Mortar, if it contains sea sand, would

absorb moisture on account of the particles of salt present in it which have a considerable affinity for moisture. Such materials behave like a sponge. In dry weather, they get dried up but during wet weather again, they are saturated with water.

In the case of mud walls or mud-mortar stone walls, if the mud contains free salts, they absorb a large quantity of moisture from the air. The remedy is to leach or wash the salts out before use.

---

# WALLS.

Walls form by far the most important and costliest item on the estimate of a building and it is therefore, here, that some room for economy must be found. It can best be effected, as we have already seen, by using local materials. But certain materials available at a particular place may be scarce at another. Hence, it would be well to discuss the various alternative methods of wall construction with different materials.

## FRAMED STRUCTURE VERSUS SOLID WALLS.

There has been a time-honoured pratice of building walls, in India, in which the walls are re-inforced by means of a frame-work of vertical posts and horizontal beams fixed on their tops and all embedded into the walls. In the houses of the rich, the wooden members of the framed structure used to be obtained from cut timber and therefore for the sake of decorative effect they were left projecting half an inch beyond the wall surface, while in the houses of the lower classes, they were either round rafters or roughly squared pieces embedded in the centre of the walls. The object of the framed structure was, to throw all the upper load of floors and

roof over the posts, which were further strengthened by the lateral support they received from the walls. The walls, in this instance, had practically no structural function to perform, at least in the beginning, but to serve merely as partitions and to prevent transmission of heat, or cold and sound from one side to the other, and also to afford protection from thieves in those very troublous times. The fear of robbers weighed so much with them that though the walls were not primarily intended to take up the load above, they were built very thick–3½ft. to 5 ft. or even more in some cases. The extra thickness was utilised in most cases for a staircase which was accommodated in the body of such walls.

Apart from the numerous merits of this system of framed wall construction, which have been discussed in the author's treatise "Modern Indian Houses etc." there is a great outstanding disadvantage in it, which at once eclipses all its merits. It is in the fact, that the members of the frames which consisted of wood were subject to the attack of Dry Rot* and termites (white ants), the greatest enemies of wood in India. Particularly dry rot works its mischief, as we have already seen, in places which are damp and which have a deficiency of free air. Now, in the situations they were used,

---

* Please see page 20

either partially or fully buried in the walls, they could not get free air, and moreover, the defective drainage arrangements to which these old houses were usually subject, caused also damp to rise. Thus rot first started in the bottom of the posts which gradually spread to the top and ultimately attacked the post plates also. The natural result of this defect was, that in many cases the frame members having been hollowed out could no longer support the load, which consequently fell upon the walls. The secret of the long life of such old houses lay in the extraordinary thickness of the walls. If they were of ordinary thickness of 18 inches they would certainly have crumbled down in a shorter period.

Thus a framed structure should not commend itself to any body unless either the walls are built of extra thickness, which, in these days of restrictions of space and funds, is not likely to find favour with people, or steel is substituted for wood of the frames. This sort of construction would do well for temporary sheds, farm houses, barns, stables and cowsheds etc., but not for permanent structures built as an investment.

From the point of view of economy also, it may be noted that where special "white earth" which is generally used for preparing mud mortar for such walls either of stone or burnt

brick, costs more than Rs. 6/- per 100 cft, including carting charges,this sort of construction even with round teak rafters for frames is more expensive than solid walls built in lime mortar.

It may be mentioned here incidentally, that for a ground floor structure only, that is, for a house without any storey, if 18 inch thick walls in mud mortar are well founded and built perfectly in plumb, no reinforcement of posts etc. is required for supporting the load of the roof. If one or more storeys are to be constructed, the most economical and efficient method is to reinforce them by means of some sort of slender steel columns.

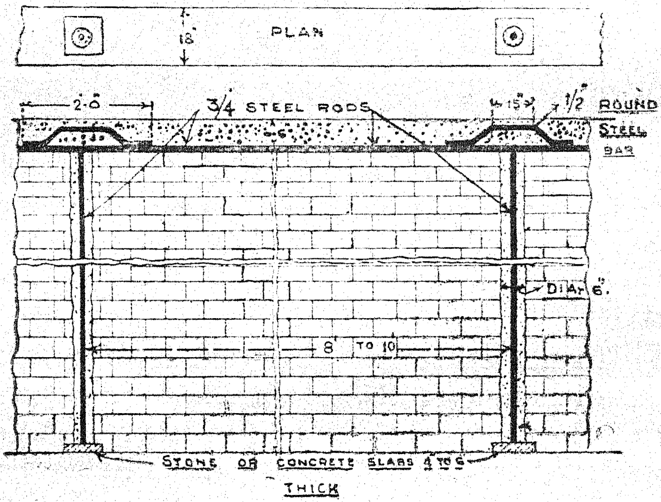
Recent tests made by the Bureau of Standards, in America, have conclusively proved that such columns, if rigidly fixed all round in the centre of the walls so as to prevent any bending or buckling, can be counted on, to carry loads up to the yield point of steel, before failure occurs. The columns may be in the form of either galvanised iron pipes, of say, 1½ inch diam., filled with cement concrete, with wall-plates also of same connected to them with T pieces, or even better still, I-beams of the lightest section viz. 4″ in. × 1¾ in. weighing 5 lbs. per foot of length, with cement concrete filled between the flanges. Even at the conservative

rate of Rs. 7/- per cwt. to allow for market fluctuations and reasonable transport, the above I-beams cost annas 3 per foot and if annas 2 are added to it for the cement concrete and labour of joining and fixing, the aggregate rate of annas 5 per foot length compares favourably even with round rafters of timber and is absolutely free from the danger to which wood is liable.

It is possible to make it even cheaper if the following method is adopted:—

Instead of wooden posts and post-plates above them, erect ¾ inch round bars of the necessary height with bottom placed on Shahabad or other slabs, at least 4 inches thick and 12 inches × 12 inches at least in length and breadth. Tie on their top another horizontal bar of the same thickness and another small piece bent as shown in the sketch, Figs. No. 3 & 4, 4 inches above it, tied down by means of a piece of thin wire. After this is done, regular wall of stone or burnt brick in mud may be commenced leaving in each layer an irregular hollow space, of say, some 6 inches diam. all round the iron rod and fill it up, each time, when 4 layers of brick work or about 12 to 15 in. of stone work is built, with cement concrete. The objects of this are (1) to protect the steel against rusting (2) to give it the necessary stiffness against bending or buckling and (3) to form, in other words, a rein-

forced cement concrete pillar and beam on top without centering. When work is commenced




Figs. 3 & 4.

the next day, the concrete surface of the previous day should be roughened before fresh concrete is added. The vertical rod should have no joint. The horizontal rod can be lengthened by tying two ends of rod with an overlap of nine inches by a wire. When the level of about 1 inch below the horizontal rod is reached, the edges of the wall may be lined with bricks laid flat or stones, and a hollow space of 6 inches may be left with the iron rod in the centre. The rod should be so placed that there will be a hollow space of one inch below it. This and the space above it may be similarly filled with

cement concrete so as to form a rough concrete beam of 7 or 8 inches thickness.

With the foregoing discussion about framed structures we now turn to the subject of walls.

The materials forming the composition of walls are of two sorts: one is called the aggregate, such as stones, bricks etc. and the other is called the binding or cementing material, like mortar. The latter may consist of lime, cement or mud.

In an earlier chapter, while discussing materials mud mortar has been advocated as a suitable material for walls of houses of the cottage type. But while using it, certain precautions have to be taken, as otherwise, not only will the bill for the maintenance and annual repairs of the building swell enormously, but the life of the building would be shortened. These are: (1) Proper selection of the earth; (2) Guarding against damp or any sort of moisture entering the walls and (3) Protection against rats and white ants.

The subject of selection of the proper earth will be shortly treated in detail under Earth walls.

Prevention of damp in walls is a matter of very great importance, because, damp is not only detrimental to health as already seen, but it also affects their strength. To what extent

it does so, will be clear from a very common instance. Everybody knows how hard and tough the dry clods of earth in a ploughed field are. Many of them will bear the full weight of a grown-up man standing upon them. But notice what happens when a slight rain drizzles over them. The clods in the entire field are at once reduced to powder, as if by a miracle, and lie flat on the ground. This clearly indicates what an adverse effect moisture has on the strength of a clod or lump of earth.

The main sources of moisture entering the walls are three as already mentioned (1) Moisture rising from the foundations or ground from below in the form of damp (2) Water from a leaky roof soaking directly (vertically) from the top into the wall and (3) Water from driving rain penetrating through the joints and the pores of the material composing the exposed surface of the wall.

The first two sources, viz. moisture from the bottom and top of the wall, are very important in so far as the quantity of water is concerned as compared with the third. That is to say, if we provide watertight shoes and hats to the wall, we are sure to exclude the main bulk of moisture. Coats in the form of some special water-proofing treatment must be provided where the material used in the exposed surface is porous and this precaution ought to

be taken particularly in regions subject to fierce monsoons which continue for a long period.

Enough has been already said on pages 47 to 49 about the first source. The question of protection against damp from leaky roofs will be discussed under roofing. For protection against the driving rain if the wall is of stone, pointing the joints with lime or cement is sufficient. If it is of brick, the surface has often to be plastered with lime; however, this not only involves a great initial cost, but the repairs of the plaster and the renewal of the colour are items of considerable recurring expenditure. Coarse grains of sand mixed with cement dashed against the wall surface to form what is called "Rough cast" is more permanent and cheaper in the long run, but gives lodgment to dust. Other methods of water-proofing exposed surface will be dealt with in their proper places while describing various forms of wall construction with materials other than stone and brick. Projecting long eaves affords some protection, but they interfere with free breeze of wind and light entering through windows and doors.

Regarding the third precaution, viz. protection from rats burrowing under walls, and white ants eating out timber used in the structure, the subject has been treated in a special small chapter elsewhere in this book.

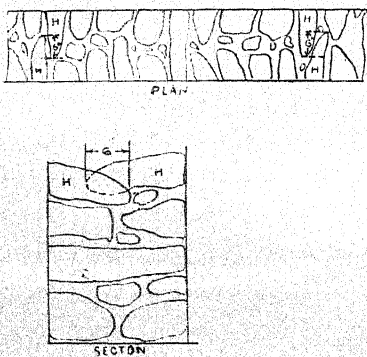
## 1. WALLS OF STONE.

Now we shall return to the different methods of building walls with whatever material may be locally available. Stone and brick are the most common materials. If stone is used there are two methods of building walls; one, which is called the coursed rubble, requiring faces of stones to be dressed to a rectangular shape. In this, the face of the wall has long lines of horizontal joints, with all the vertical jonts at right angles to them. This sort of construction is pretty expensive. The other sort presents irregular joints in the face work and is called uncoursed rubble masonry, because, there are no regular courses in it. This is not only comparatively cheaper but also looks artistic.

With the use of mud as the cementing material, every little point, which tends to make the wall strong, can not be neglected. Hence, it would not be amiss to point out, in passing, the common mistakes made in practice and the necessary precautions required to avoid them in the above two methods of stone walls.

The first precaution is the use on a generous scale of through stones or "headers" as they are called, that is, stones with their length equal to the full thickness of the wall. Their function is to bind the two faces of the wall together. They should be spaced, in each course defined by the corner, at a distance of

6 ft. When the corner stones for a course are fixed at the two ends of the wall, the headers for that course should be placed in their positions and then the intermediate spaces between them should be filled with masonry. The headers in the course above it should be so fixed that each comes midway between the two in the immediately upper and lower courses. If the headers of the full thickness of the wall are costly, two shorter ones should be so fixed side by side with their faces on the opposite sides of the wall as shown in plan and section in Figs 5 & 6 at H. H., that their tails overlap at least 6 inches as shown in the sketch.




Figs. 5 & 6

The second precaution necessary for strength is, that every stone fixed in the wall should rest on its broad surface at the bottom. Masons are in the habit of fixing stones on edges with their broad surfaces lining the face of the wall. They do it because it saves them the labour of making two or three joints which would otherwise be required and therefore they can speed up the work thereby. But this is a

dangerous practice, though the face of the wall apparently looks more elegant. Even common sense will tell us that stones which have no sufficient base to rest upon, nor tail going into the thickness of the wall to bind it are likely to slip away under pressure from above. In this connection the general rule is, that every stone used in the facework of wall must have a tail at least 1¼ times its height.

The third necessary safeguard is, that not only should there be no hollow spaces left in the wall, but that every hollow must be filled, not with mud alone, but with stones set hard in the mud with a stroke of hammer. Again, instead of a number of small stones or chips, it is better, in the interest of strength and stability, to select large ones to suit the shape of the hollow.

## 2. BURNT BRICK WALLS.

The quality of bricks manufactured in India, except perhaps in a few cases, is very poor. Especially their shape is not square and uniform, and they absorb a lot of moisture. To overcome these defects, the brick work is generally plastered with either lime or cement which increases its cost. If the annual average rainfall of a place is above 50 inches, some water-proofing treatment is necessary to keep out damp, but at other places.

if only well burnt, and uniformly coloured bricks are selected for the face work and they are laid perfectly in plumb, the work, if neatly pointed, looks quite well, even without plaster. If the experience of one monsoon shows that it affrods a sufficient protection from damp, as will generally be found to be the case at such places of low rain fall, there will be a considerable saving in the cost of external plaster.

## 3. HOLLOW CONCRETE WALLS.

Cement concrete as a cheap building material is a modern product. Great strides have been, of late, made in using it successfully even in the extreme ranges of temperature in the tropics. As it possesses considerable strength, economy can be effected by adopting a thinner section of wall. But in a hot country like India, as a thin wall is likely to make the house hot, a wall thinner than 9 in. in section can not be used especially on the outside. However, as the material is pliable when wet, hollow concrete blocks can be made. The latter afford protection from heat on account of the air space inside the wall built of such blocks. In towns and villages, served by a railway line or a good metalled road bearing motor traffic, cement concrete for cottage construction lends special charm, as clean river sand and gravel could be

obtained in plenty, in the greater part of India merely for the charges of collecting. Such buildings not only are strong and durable but are easy and cheap to maintain, keep clean, and look neat and tidy. The only difficulty is of getting machines for moulding hollow blocks on a cheap hire so as to come within the reach of a house builder of ordinary means. On account of this difficulty its use has been at present restricted to buildings of considerable magnitude only, in which concrete blocks are required to be manufactured on a large scale. However, concrete as a cheap material has a great potential future before it in India.

## 4. COMBINATION OF BURNT AND UNBURNT BRICK.

There are many places where stone quarries are not within a reasonable distance and bricks from kilns which are almost entirely burnt by village potters may also have to be carted from a distant village or a small town, At such places, a composite work of a combination of burnt and unburnt bricks may be resorted to.

The idea is to use burnt bricks only on the exposed surface of walls for making them resist the atmospheric influences and sun-dried or Kacha bricks not only for the inner partitions but also on the inner face of the exposed

walls. A further economy in this respect may be made by using clay lumps instead of regular sun-dried bricks. The process of preparing them is described below :—

Get a heap of white earth or whatever soil is available on the site, remove all roots of vegetation etc., sift it through a screen of half inch mesh. If it contains an undue amount of clay and shows a tendency to crack while drying, mix some sand or gravel with it and make a plastic mass of it with water, of such a consistency as a lump made in hand, if placed on ground, will not spread. Then on a level piece of ground sprinkle some sand or dry earth or ashes and form a roll of 10 ft. or longer according as the space will permit, 13 inches wide, and 5 to 6 inches thick, roughly squared either by hand or a flat piece of wood and cut it across into pieces 8½ inches long by passing a piece of wire vertically down across it by hand from top to bottom. Thus each piece will be roughly 13 in. by 8½ in. by 5 to 6 in. thick. The thickness will depend upon the thickness of the burnt bricks used in the face work. It should be twice their thickness plus ½ in. Thus if the burnt bricks available are 2½ in. thick, the thickness of this lump should be 5½ in. and so on. One such piece is shown in fig. 7.

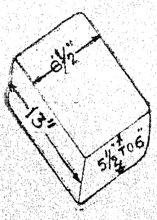


Fig. 7

Allow these pieces to dry in the sun for two days, then turn them over for drying for an another day, after which, they are ready for use in the wall. The method of constructing the wall is as follows:—

A number of well burnt bricks should be kept immersed in water for 2 or 3 hours before starting the work. Two masons should be employed, one with these burnt bricks and lime mortar on the outside face of the wall to be built, and the other, with the clay lumps and mud mortar on the inner. The mason on the outside should spread a layer of lime mortar of ½ inch thickness, and 4½ in. width along the exposed or outer edge of the wall and behind that the other mason should spread mud mortar of the same thickness and of width upto the inner edge of the wall, then the first mason sitting outside should lay bricks stretcher-wise i. e. parallel to the wall as shown in the fig. 8 leaving a space of ½ inch between two bricks, they will of course rest on lime mortar. The half inch space betwen the bricks should be filled with lime mortar. While this is being done the 2nd mason

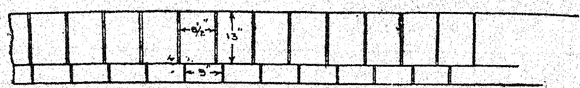


Fig. 8 First course of burnt bricks.

sitting inside should lay the clay lumps

header wise i. e. with their 13 in. side across the wall, as shown in fig. 8 making a joint of ½ in. thickness both with the burnt bricks already laid and with another clay lump laid by its side, filling it with mud mortar.

For the 2nd course of burnt bricks the first mason should spread another layer ½ in. thick and 4½ in. wide of lime mortar as before on the top of the layer previously laid, and lay bricks stretcher wise as before but breaking joints in the centre of the bricks previously laid as shown in fig. 12. The 2nd mason should fill

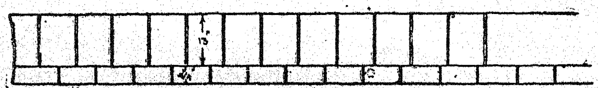


Fig. 9 2nd course of burnt bricks.

in the joint between this layer and the clay lump already laid, with mud mortar. This completes one course of the clay lump, as the thickness of clay lumps is twice that of the burnt brick plus ½ inch. The top of the wall at this stage will be roughly level.

The first mason should then spread another layer of lime mortar ½ inch thick and 4½ in. wide as before and lay bricks near the outer edge headerwise i. e. 9 in. length across

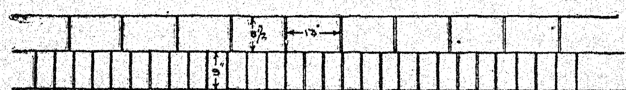


Fig. 10 3rd course of b. b and 2nd of clay lumps.

the wall as in fig. 10 making a vertical joint ½ inch thick between two bricks; on the top of this another layer of lime mortar to be spread as before and another course of bricks laid headerwise as before, as shown in fig. 11

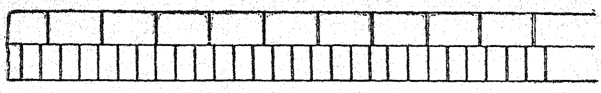


Fig. 11 4th course of b. b and 2nd of clay lumps.

but with joints coming exactly over the centre of the bricks below. The inner mason should lay lumps stretcherwise i. e. 13 inches length parallel to the length of the wall as shown at in figs. 10 and 11 taking care to bring the front surface in plumb and filling joints of bed and the sides well with mud mortar.

After this, two stretcher courses of burnt bricks on the outside in $4\frac{1}{2}$ in. width of lime mortar and a header course of clay lumps behind it laid in mud is to be repeated and so on.

An elevation of such a wall is shown in fig. 12 and a cross section in fig. 13.

Fig. 12

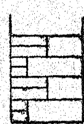


Fig. 13

The points to be specially noted in this sort of construction are:—

1. That the mud mortar should contain a little more sand than usual and it should be used a little stiff i. e. just sufficiently wet as would enable it to be thrust in the joints with a mason's trowel. These precautions are necessary because we have to join mud work with lime mortar work. Mud mortar shrinks more than lime mortar. If the mud mortar contains more water it will shrink more and a crack will be formed at the junction of both the mortars. Ad-mixture of some sand and use of as little water as possible in the mud mortar, would cause it to shrink less. The object to be aimed at is, to make the coefficient of shrinkage of both the mortars, equal. This may be tried by an experiment and if required the lime mortar may be made slightly more wet. It is for this reason, necessary, that the burnt bricks must be kept well immersed in water for a sufficiently long time before being used. Otherwise, they would absorb moisture from the lime mortar and affect its coefficient of shrinkage.

2. The mason using lime mortar should be made to take special care in filling the joints neatly i. e. making them of uniform width, and making the horizontal joints exactly at right angles to the vertical, while laying the masonry in the first instance, so that, there should be no necessity of pointing them again.

3. Water should be sprinkled freely to help lime mortar set hard. It should not, however, be done on the top of the wall but on the exposed face, because the water on the top might enter the mud mortar or clay lumps and thus damage the wall.

4. If the foundations are sufficiently sound it is not necessary to reinforce the wall with posts etc. if the building has no storey. 18 in. thick walls constructed in the above manner will easily sustain the weight of the roof.

5. There is no need of plastering the inner surface of walls if it is made plumb and smooth just while laying the clay lumps, by dressing the projecting portion with a mason's axe and applying mud mortar mixed with a little cow-dung, in the hollows.

6. The inner surface thus prepared should then be given a wash with a mixture of 12 parts of white earth, two of cowdung and one part of cement, and may then be treated with two coats of white wash.

7. Lintels over doors and windows should go a little longer, say, about 9 inches at least into the wall on both sides of the opening.

8. If a water-tight roof, say such as, that of C. I. sheets is constructed, the house with walls as above looks like a pucca structure and does really behave as one.

## 5. WALLS OF EARTH.

Earth walling is of great antiquity in India. Even to this day, it is the common practice in villages and towns in every part of the country. Recently it has been gradually falling into disuse particularly in towns, perhaps on account of improved facilities of transport.

Earth is specially well adapted for walling in country districts away from large towns where a suitable variety of it is available in plenty merely for the collecting, where skilled labour is costly and unskilled labour cheap, and where site is not much restricted i. e. work of rather a bulky nature is not only admissible, but would rather conform to the general surroundings.

If earth walling is adopted it is necessary to modify the design to a certain extent as given below :—

(1) The exterior angles of corners should be rounded.

(2) Projections and recesses in walls should be avoided. Bays and ingle nooks are unsuited to earth walls.

(3) As far as possible walls upto the plinth level should be built of stone or burnt brick ; but if a good slope away from the walls is given to the ground, so that rain water as it

drops from the eaves, flows away rapidly, there is no harm if the plinth is also of earth.

(4) The eaves of the roof should project a little longer than usual, so that the top portion of the walls is protected from rain.

(5) Water-tight shoes and hats i. e. foundations of non-absorbing material, and a non-leaking roof should be provided.

Earth as a material for wall really possesses a good many virtues to commend it for more general acceptance. The special advantages which it commands over the stone or brick are given below:—

(1) It is the cheapest and easiest form of walling. Stone costs something for quarrying, carting and dressing; brick costs something for moulding, burning and transport. Earth alone is the only material which can be dug near the site and used directly into the fabric of walls without any elaborate or costly process of conversion.

(2) An earth wall can be built by an unskilled labourer or farmer. For stone or brick walls one has to depend upon mason and other men of the artisan class.

(3) Earth being a far better insulator of heat, houses of earth walls keep cool in summer and retain warmth in winter. Hence,

they are found to be more comfortable. Besides, as constructing a slightly thicker wall of earth costs only a trifle more, it is within the easy reach of the poor, to secure greater comfort at a little extra cost.

(4) The repairs and renewals are very easy and cost very little, e. g. mud plaster can be cheaply and easily renewed. Lime mortar does not stick so well to old mortar which has already set. This is not the case with earth. Again, if brick work is dismantled there is some loss of bricks in breakage. If, however, an earth wall is dismantled nothing is lost.

(5) The progress of the work can be speeded up to any extent.

(6) They are far less susceptible to destruction by an earthquake than either stone or brick walls, as has been already proved recently in the earthquakes of 15th Jan. 1934 in Bihar. This is a very important discovery and this fact should be borne in mind in the reconstruction of Bihar.

(7) As the material from the immediately surrounding locality is used, earthen walls conform to the harmony of the neighbourhood.

(8) Earth walls are more secure from fire than stone walls. Stone when subjected to heat for a long time cracks and splinters.

There are three methods of earth walling: (1) Walls with sundried bricks (2) Walls built with mud in situ and (3) *Pise de terre*, or walls of rammed moist earth. The first is very common even to this day in towns and villages. This form of walling is extensively used for internal partitions. The second method was once very much in vogue, but has almost died out at present though its rude technique is found to have been still preserved by very poor farmers in remote villages. The third is almost unknown in India though it has many merits to commend itself for general adoption by middle and lower class people. It has been very extensively practised in western countries in spite of great natural disabilities obtaining there, such as the absence of dry weather and hot sun.

## 5 (a) WALLS OF SUN-DRIED KACHA BRICKS.

The reason why this method is more popular than the other two is, the convenience and ease with which it can be worked. First of all, the kacha bricks can be moulded at leisure, dried and kept ready, and work commenced at any convenient time later on. Secondly, walls of any desired thickness can be built according to the size of the bricks moulded, and thirdly, the plastering or giving a wash of white earth and

cowdung can be taken in hand at some later convenient date. The only important thing is, that all the operations must be done before the rainy season begins. If the bricks are ready, actual building work does not require much time.

Any soil would be suitable. Of course white or impervious earth described on page 27 is the best. But if either of these is not obtainable on site any other soil would serve the purpose, provided the bricks formed of it, do not crack much during the drying process. In that case, some sand or better still, rock powder or fine murum should be mixed with it. If the structure is single storied, 18 in. thick walls can easily take up the load of the roof and wind pressure, without any reinforcement of vertical posts. For a two-storied building, the thickness should be 21 inches throughout for both the floors, if reinforcing posts are not used. If space permits, thicker walls like this are preferable, both from the point of view of cost and protection from heat, to walls of a thickness of 18 inches or less, even if reinforced with posts of wood. For, unless well seasoned cut teak posts are used, they are liable to be attacked by white ants or to disintegrate by dry rot. For a two-storied building, a thickness of 21 in. throughout is recommended because, if the walls of the upper storey are made 18 in. thick and flush

with the outer edge of the lower walls i. e. if the offset of 3 inches is left on the inner side, the centre of gravity falls towards the outside and the walls are likely to tilt on that side. If on the other hand the upper walls are built in the centre leaving equal offsets of $1\frac{1}{2}$ inch on either side, the rain water striking the outer surface is likely to soak through the outer offset unless a string course of some water-proof material with a drip mould to allow the water to drop away from the wall is provided at a considerable cost.

It is possible to make this sort of walling still cheaper by using earth lumps described in the previous chapter instead of regularly moulded bricks.

## 5. (b) MUD WALLS BUILT IN SITU OR "COB WORK".

Once a very common method of wall construction, it has now almost died out in this country. It is still seen practised in some remote villages by indigent people. They take one or two off days from their farm work and men, women and children–members of the entire family concentrate together and build a hut for themselves, because they cannot afford to employ the services either of a skilled artisan or even of a slightly skilled fellow farmer. Again, the whole aim is to finish the work in a

minimum period to save time for field work. They are, therefore, content if the hut just gives the family a shelter from the inclemency of weather. Hence, no attempt is made for obtaining uniform thickness of the wall or to test the surface with a plumb ball. The wall is generally crooked and tapering towards the top. It is built simply by piling lumps or balls of mud one upon the other, and wiping the surface smooth by hand dipped in water. No attempt is made to build the walls solidly on a sound footing; hence, they begin to crack soon afterwards. The hut is invariably covered with a thatching of hay, paddy straw or even leaves of palm trees, of inadequate thickness, with the result that rain water soaks into them, and as there is generally no plinth provided, damp also rises from bottom. Thus the whole thing presents an appearance of neglect and squalour.

Mud, however, forms an excellent material for wall construction, the virtues of which are not put to a proper test and appreciated in these days. Our forefathers knew the secret of construction very well. We still see old neglected forts or ramparts 30 or 40 ft. high still enduring, though in a ruinous condition, encircling villages or towns built formerly for protection from the enemy's attacks in those troublous times. They used stones for the faces up to a certain height, and rammed mud

between them for the hearting, and above this height mud appears to have been used even on the faces. Years amounting to two or three centuries have rolled on, they have never received any care of repairs at human hands, but on the contrary every neglect and contempt, still they stand obdurate all these years in defiance of the fury of Nature; what more triumph can there be of the enduring power of Cob work?

To quote another instance the famous fort of Bharatpur near Agra, one of the most unvulnerable strong-holds of the Jats in India at that time, was built entirely in mud. It had been several times besieged by the English and bombarded with heavy guns on several previous occasions; but without success, so much so, that this led to the establishment of a superstition to be associated with it, that, as angels protected the fort, it was not possible for any human effort on earth to capture it. At last it was when a strong contingent of army, under Lord Comberemere, was despatched and, only when an extraordinarily heavy mine of gun powder, on a scale hitherto unknown, was applied at the bottom and fired, that a piece of the rampart was bodily lifted with men on it and hurled into the sky. And through the passage made by it the British troops made their entry and captured the fort in 1826.

The Jat king constructed the bulwork in preference to stone, not because stone was scarce or because he could not afford it, but because he knew confidently that a mud fort was stronger than one of stone and the result proved that he was justified in his conclusion.

There is a considerable evidence to show that this form of wall construction was once very common in domestic buildings but some how or other, it came to be forgotten and now it is almost extinct. The correct process of doing it is described below:—

The foundations should be first excavated up to murum or rock if the latter be found within a reasonable depth below the ground surface, or to a firm soil (except deep black cotton soil which requires a special treatment), and the trenches should be filled with boulders of stone, rubble, or burnt bricks, if stone is not available within a reasonable distance, using mud mortar. It is advisable to use stone or burnt brick upto the plinth.

The ground from which earth for preparing cob is to be utilised, should be cleared of all vegetation, the upper 9 inches layer of it which is full of roots of vegetation, decayed matter etc. should be removed and the stratum below it should be excavated and used. All lumps should be broken. The more impervious

the earth is to water, and free from swelling when wet and from cracking when dry again, the better it is for cob work. It is screened to exclude stones above one in, in diameter. A circular heap is made of it with a hollow made in the centre at top which is filled with water and kept in that state for several days for "souring". Then wheat or rice straw is sprinkled over it freely and the wet earth is drawn by a phaorah and mixed while a man is sprinkling more water over it by means of a rose of a water-can. It is then well trodden under the feet of workmen and thoroughly incorporated. Some people mix dung from horse stables in it.

Lumps or balls of the cob are then formed which should be just stiff enough to afford ease in laying; if they contain more water, they spread and the wall bulges out.

Diagonal layers, instead of horizontal, ones laid as shown in the sketch, (Fig. 14.) are stronger. Each layer is trodden under the feet by the man who stands on the top of it. In most cases, shuttering is not used, but the extra earth on the wall surface is pared after 24 hours, with an instrument having an iron edge to which is attached a long wooden handle.

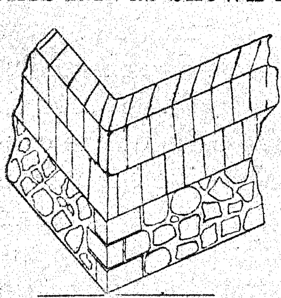
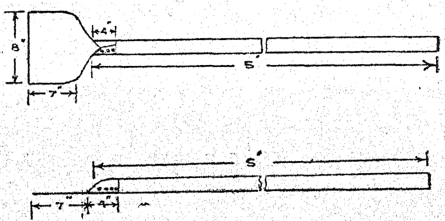


Fig. 14

(See figs. 15 & 16.) A plumb line should be used



Figs. 15 & 16. Paring instrument plan and Side view.

at this time to make the faces truly vertical. If the lowest one or two feet, or say, the plinth masonry is constructed even in mud, but of either of stone or burnt brick, on the outer face (which is strongly recommended in the interest of keeping the walls free from damp,) it is very easy to keep the rest of the upper surface of cob work in plumb with this. Each course is 12 to 18 inches thick and is laid between horizontal strings stretched on both sides of the wall. As each layer is being laid, it is trodden by the man standing on the top of the wall and receiving the balls of cob. Since very little water is used in the preparation of the balls of the cob-just so much in fact, as would give the necessary pliability to the material for ease of work, each layer dries up sufficiently to take up the weight of another above it, in about two hours in this country, if the work is done in summer.

The thickness of the wall depends upon the height to which it is to be raised. For a single storied building 21 to 24 inches thickness is sufficient both from the point of view of their own stability, strength for supporting weight of the roof, and protection from heat and cold. The internal partitions are best made of unburnt bricks 9 to 18 inches thick, to save space. In Europe even two storied houses of cob walls, *without* intermediate supporting posts, have been constructed and have stood well for over hundred years in spite of the wet weather which prevails there for almost 12 months in the year.

As the work progresses and the wall reaches a height not easily accessible to labourers handing lumps or balls to the men standing above it, a sort of tool consisting of an iron fork with a wooden handle as shown in the sketch, (see Fig. 17 & 18) is used for reaching the balls

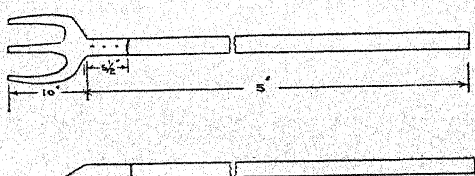



Fig. 17 & 18 Plan & side view of the fork.

to the man above. The surface of the wall constructed is pared and made smooth and plumb after 24 hours. It is then given a wash

on the inside and outside, of white earth mixed with a certain proportion of cow-dung.

On the top of a door, window or cupboard opening, lintels of wood, or, if trouble from white ants is feared, of R. C. C., may be placed. The point to be remembered is, that they should be sufficiently long, projecting at least one foot over either corner. There are two methods of making door and window openings. In one the frames of doors or windows are erected in position by supporting them temporarily with inclined stays, when the wall work reaches their bottom level, and the wall built between them as usual. In the other method, wall is first built solid with only the lintels fixed at the proper levels in it and afterwards the recesses for doors and windows are cut through below them, and frames fixed in them. The 2nd method affords ease in construction, but as frames cannot be fixed by means of iron holdfasts, well anchored in the body of the wall, they are likely to be a little shaky in course of time. All outside corners should be widely rounded, that they may present a neat appearance and be not susceptible to be easily knocked off. The corn ers of door and window openings should be chamfered as usual.

*Roof* :—A hipped roof is more suited to this sort of construction as the walls need not be raised so high as in the case of gables. Again,

the latter expose greater unprotected surface to rain.

Any roof covering may be used, provided it is water-tight. In this respect, a roof of corrugated iron sheets, with sheets bolted to wooden wall-plates on top of walls, is excellent. For preventing iron sheets being blown away by high wind, the wooden wall-plates may be fastened down by means of wire ropes well anchored in the walls. A thatched roof looks more in harmony with cob walls, but 1stly it is insanitary, and again, it affords a breeding place for rats, and is likely to catch fire, and lastly, if not well cared for and repaired from time to time, it is likely to leak. The c. i. sheets may be coverd with thatch if desired, as it will serve to keep off heat effectually.

The mode of water-proofing the outside surface of earth walls in general has been discussed at the end of the next chapter.

## 5. (c) PISE DE TERRE.

'*Pise de terre*' is a French expression for "Rammed earth". This method of construction does not appear to have been practised in India. It is, however, an excellent and cheap method and most suited to Indian conditions. Hence, it has been treated at considerable

length in the following few pages. The author has experimented on it on a small scale and found the results most promising.

Nothing would be better than to quote Mr. St. Loe Strachey, an authority on Pise building.

"As we do not possess the crystal air and intense sun heat of Australia, the earth walls do not harden in England."

We, in India, are very fortunate in possessing the advantage of this "crystal air and intense sun heat."

To proceed with the quotation, "that heat evidently produces a skin, which must be almost like brick. At the same time even in our English climate, the eighteen inch wall becomes perfectly strong and substantial for all practical purposes. As, however, it had to face the rains of an English autumn, and winter, I have had the outside covered with a mixture of coal-tar and pitch, which produced a surface very much like that of a tarred road on end, and is quite satisfactory. On the inside of the building the face is left untouched, and has already become very dry and hard. It is evident that it will make a peculiarly good wall for a house."

There is a very interesting account given of a pise church written by Abraham Reed, D. D., F. R. S. F., L. S. in volume XXVII of

the Cyclopeadia or Universal Dictionary of Arts, Sciences and Literature, from which is extracted the following quotation :

"A pise Church—The Church was the most remarkable in this style of building; it is about 80 ft. long, 40 ft. broad, and 50 ft. high; the walls built in pise 18 inches* thick and crepe, or roughcast on the outside, with lime and sand. Soon after my arrival, the Church, by some accident, was destroyed by fire and remained unroofed for about a twelvemonth, exposed to rains and frost. As it was suspected that the walls had sustained much damage, either by fire or the inclemency of the season, and might fall down, it was determined to throw them down partially and leave only the lower parts standing; but even this was not done without much difficulty, such was the firmness and hardness the walls had acquired, the Church having stood for over *eighty years*, and all the repairs required were only to give it on the outside, every twelve or fifteen years, a new coating of roughcast."

The essential difference between cob work and pise work is that whereas in the former mud is prepared with a free use of water, and straw is added to it, in the latter, the earth

* N. B. the 18 in. walls were carried to 50 ft. height *without* any vertical posts to re-inforce them !

which is just moist, is rammed between boards or planks laid on both sides of the wall, and not only no straw is added to it but every bit of root of vegetation is scrupulously picked up and thrown away from it. Another difference is, that cob work, on account of its plastic condition does not admit of ramming hard, while, the success of pise work lies in quick and hard beating of the earth in moulds.

## SUITABLE SOILS.

Soils are sometimes called stiff or light from an agricultural point of view, according as they offer greater or less resistance to the plough. The stiffness is due to the greater proportion of clay, and the lightness, due to that of sand. The soil suitable for wall work should be neither heavy nor light. Between these two extremes there is a very wide range of soils which are suitable. The soils at these extremes also can be made suitable by blending them together in proper proportions. But no sooner complications of this nature enter, the pise work loses its greatest virtue of cheapness, because, one of the two soils has to be transported and also labour wasted in the process of mixing the two together.

Fine silt in the river bank is eminently suitable, so also silt from canals or tank beds.

Soil denuded every year by rain from hill slopes and deposited at the foot, is very good.

All earths which are suitable for brick or tiles, form an excellent material for pise. Thus, between the excessively heavy on the one hand, and the excessively light on the other, there is a countless variety of soils which are suitable. Of course, some of them are better than the others.

Before deciding upon the final choice of a particular soil for work, it would be well if the following simple experiment be made.

Dig a pit in ground, say, about 3 ft. by 3 ft. and 18 in. deep. Then take a bottomless iron bucket of ordinary size and put it in the centre of the pit on a piece of stone slab or a wooden plank. Put the earth selected for the pise work into the bucket to form a layer of 4 in. in loose state; also put the other earth excavated from the pit, round the bucket to form a layer of equal thickness. Ram both the earths hard until the layers are reduced to half their thickness. Then add on their top, layers of similar thickness, taking care to consolidate each before another is added; continue this till the top of the bucket is reached. Let it remain in that condition for 24 hours, after which, dig out the earth in the pit outside the bucket, till the latter, with the lump of earth inside it, can be lifted up. Take the bucket out and make it

topsy turvy on ground, with the broad mouth down. Hold only the bucket now in hand and lift it up so that it comes off leaving the lump of earth on the ground. Protect its top by means of a slab or a piece of board from rain if any likely to fall, otherwise, let it be exposed to sun and wind quite freely. If it does not crack, but goes on hardening every day, as it dries up, the soil may be taken as quite suitable. If, on the other hand, it forms small cracks, it needs sand or some light soil to be mixed with it. This should be done and the experiment repeated until the exact proportions are determined.

Another test is to make balls of earth, with or without mixture of sand and watch their behaviour in respect of cracking and hardening. The mixture which gives the best results may be employed in the bucket lump test, mentioned above.

*Foundations and Plinth*:—The foundations should be like those usually made for the burnt brick masonry. It is desirable to use stone for foundations and plinth, and if stone be scarce or costly, then burnt brick. This is necessary to protect the pise work from the splashes of rain water dropping from eaves, or streams of storm water scouring the side at the bottom. If lime is cheap, its mortar may be used upto the plinth. This will ensure a dry bottom for the

pise walls and further, besides increasing their strength and longevity, afford protection from the inroads of rats and especially bandicoots, which have a nasty habit of digging out heaps of earth from below the walls.

The site from which earth for the pise work is to be obtained, should be excavated to a depth of 9 in. and all the stuff dug out, removed, and thrown away, as it is bound to contain roots of vegetation which are to be scrupulously excluded from the pise work. The soil below it should be excavated and all lumps broken by means of a wooden handle. Stones and pebbles above the size of one inch should also be picked out.

*Moisture*:—The correct degree of moisture is a very important factor. In most cases the soil at this depth below the ground surface, if used fresh, will contain sufficient moisture. The test of the correct quantity of moisture is, that the soil should neither jump under the stroke of the rammer, nor stick to its bottom. 8 to 15 p. c. of moisture is found to give the best results. If the earth contains but slightly more moisture than that necessary for good consolidation, the mass of earth below the rammer becomes elastic and deadens the effect of ramming; and though the surface sinks below the rammer, it rises up elsewhere. Thus, a little too dry and a little too wet earths are both bad,

though a little too dry is a lesser evil. It should be just moist enough to be crumbly and yet adhesive enough to retain the impression of fingers when pressed in hand.

*Boxing*:—When the earth of the proper consistency is prepared, boxes are placed in position. For economy and good workmanship properly designed boxes are necessary. The chief desiderata of good boxes are: (1) That they must be of such wood that it will not swell under the action of moisture, nor warp, nor buckle under the pressure of ramming. (2) That they must admit of easy fixing and removing, and still be rigid enough to stand true and square under the heaviest ramming. (3) That the space between the two sides of the shuttering must be as little obstructed as possible. (4) That there must be an arrangement for putting stops for door and window openings. (5) That the tie rods must admit of easy removal without injury to the work already done. (6) The corners in particular, must be very rigid. (7) The entire mechanism must be light, simple, easily repairable and fool-proof.

Deal wood boards 1½ in. thick serve the purpose best. There is a lot of scope for the inventive brain to design and perfect a form of boxing which would satisfy the needs under the severe climatic conditions of India. A type of boxing which has proved, by experience,

to be well suited is shown in fig. 19. It consists of 4 deal wood planks 8' to 10' long, 9 in. wide and 1½ in. thick, joined together by vertical teak battens 4 in. by 1½ in. screwed on to them. For clamping these in position, so that they should not move apart or deviate even a bit from the plumb line, vertical posts of teak wood 3 in. by 3 in. and cross pieces of wood at top and tie rods of ⅜ in. iron bar at bottom and centre are required for this.

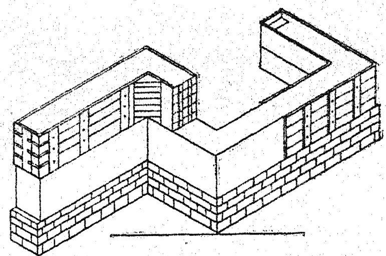


Fig. No. 19 :—Showing how shuttering or boxing is fixed. The plinth is of burnt bricks. Boxing has been laid in position above it on the right hand side for the first course, and on the left hand side for the 2nd course.

It is likely that the cost of such shuttering would be high—rather disproportionately high, for a small single cottage, and also out of the reach of the poor cottage builder, but if 3 or 4 house builders combine together, or contractors get them made and use them successively on several works, the expenses might be distributed over all of them and the incidence of cost, on any single cottage, would be small.

On an ordinary work two straight boxes, two corner boxes and four stops for blocking up for doors and windows, would suffice.

The boxes should be so placed that they overlap the plinth masonry or the pise wall already laid, at least 6 inches. as shown in fig. 20. The surface below, should be slightly moistened, and loose earth containing sufficient moisture should be spread in 4 in. layers at a time. Each layer should be rammed hard and consolidated till it is approximately reduced to half its original thickness.

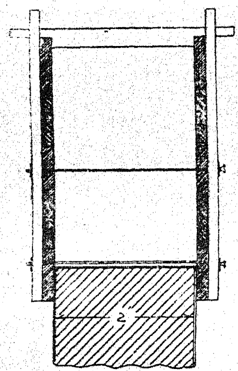


Fig. 20

*Rammers*:—The ordinary rammers used for consolidating road metal or concrete, are of no use for pise work. Three rammers of different shapes are required. The one shown in fig. 23 is V. shaped. Its peculiar shape causes the pressure to be concentrated on a smaller area, and prevents mud sticking to it; again, it can be used towards edges and corners. The one shown in fig. 22 serves the same purpose better as it is heavier. After using these for some time the one shown in the fig. 21 which has a flat bottom should be used. This distributes the pressure evenly on a large area, and is useful

also for surfacing. The rammers should be either of iron or hard wood. If wooden, the surface should be quite smooth. A layer should be said to be sufficiently rammed when the rammer thrown from a height of 2 ft. does not leave any mark on the surface. At junctions a slope should be left. Edges and angles should be rammed with special care. Hard ramming is the secret of the pise walls. It forces out the moisture and brings the particles closer together, which causes their cohesion to increase enormously, and prevent the earth from shrinking and cracking.

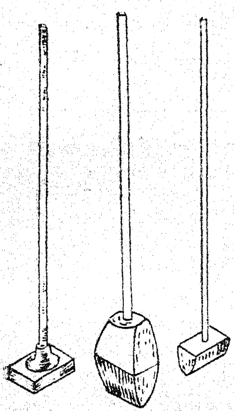


Fig. 21, 22 & 23

A special point should be noted while ramming, viz. that the rammers should never work in unison, i.e. the workmen should not strike the rammers at just one and the same time, but one after another. Because, if they do it all together, severe vibrations are set up in the entire wall, in consequence of which, it may likely be separated from other walls, not under rammers.

At the close of each day's work, it is necessary, especially during summer, in this country, to cover the top of the wall with moist gunny bags.

*Speed of work*:—For Indian climate it is advisable to fill and ram the boxes by day and allow them to remain in that position during night so that, the earth in moulds, shrinks sufficiently for the easy removal of the boxes in the morning, which should then be put up again. Out of the total height of the box, six inches go in the overlap. Hence, if they are 3 ft. high only 2½ ft. are useful. Therefore, 3 to 4 ft. boxes may be used according to the strength of the labour available.

Lintels over doors and windows may be fixed at the proper level as usual, with the only proviso that their ends should spread out at least 12 in. on each corner.

Jambs of doors and windows may be formed by arranging the stops at the particular angles.

*Beams*:—The pise walls are capable of bearing not only the weight of the roof but also of floors. Actually buildings three storeys high have been constructed; two storey buildings are quite common. These are without any wooden or iron posts embedded in the walls, but, beams laid directly on pise walls, upon which the

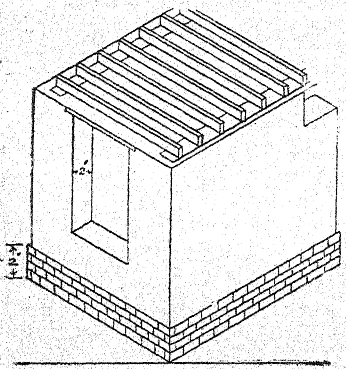


Fig. 24

floors are built. The ends of the beams should rest on pieces of boards of hard wood 3 or 4 ft. long, so that the presure may be distributed on a larger area. Fig. 24 shows common rafters laid directly on a wooden plank on the top of pise walls.

For fixing pegs, picture rails etc. plugs of wood may be built in to the pise wall during the construction at the proper levels.

*Plastering*:—It is not necessary to plaster the inner surface of walls at all. All that is required is, to pare or dress it by means of a shovel or paring instrument (fig. 15page 82) and make it smooth with a mason's trowel laid flat and rubbed against it. If necessary the trowel may be occasionally dipped into water. However, if it is desired to plaster the wall surface, it is necessary to make marks or dents on it close together by means of some edged wooden or iron instrument. This is better done when the wall is fresh and wet. After some time the extra loose earth should be removed with a hard coir brush, water sprinkled over it, and a thin coat of plaster of either cement mortar or lime mortar applied to it. It is essential that the wall should be thoroughly dry before the plaster is applied to it, otherwise, the moisture will cause the plaster to peel off. Indenting the surface is quite necessary to give a key to the plaster to stick to the wall.

*Roof*:—Rafters should be nailed to the wall plates laid on the top of walls. The roof must be absolutely water-tight and it should project a little more than usual beyond the eaves, to protect the upper portion of the wall from wind-blown rain.

*A practical difficulty*:—It is possible that on account of hard ramming the planks of the shuttering may bulge out a little; to prevent this, strong cross ties to bind together both the faces of the shuttering are required. If the latter are of ropes they will stretch or even break under the stress. If iron rods are used and are bolted on the outside they will be difficult to remove. Hence, two methods are found to be suitable: one, to provide wires and to cut them at the ends at the time of disengaging the boxes and allow them to remain permanently in the wall after the shuttering is removed. 2nd, when the surface of earth reaches the level of tie rods, which in this instance, should be of wrought iron bars about $\frac{3}{8}$ in. round, sand should be put into the box so as to encircle the rod. It will be found afterwards that if some suitable leverage is applied at one of the ends, the rod can be easily removed. The sand may be removed as much as possible and the holes plugged with earth thrust into them from both ends.

# WATER PROOFING OF EXPOSED SURFACE OF EARTH WALLS.

We have seen in a previous chapter, how important the question of keeping earth walls dry is, not only from the point of view of their stability but also from that of preventing damp, for the preservation of the health of the inmates. One of the sources of damp is the moisture absorbed from the wet air, or that driven by rain striking against the wall surface. The material used for water-proofing must satisfy the following conditions:

(a) It must be absolutely non-absorbent, i. e. it must be compact, and devoid of pores. Certain tallows are non-absorbent and water-proof, but they do not stand the heat of Indian climates.

(b) It must stick well to the surface so that even during changes in weather conditions it must not peel off.

(c) It must be hard enough to be not easily scratched or damaged by anything striking against it.

(d) It must be cheap and also pleasing to the sight.

A few suggestions are given below :—

(1) The usual method of giving an annual wash to the wall surface with white earth and

cow dung, mixed together, applied by hand does really protect the wall temporarily from wind blown rain. This may still be improved upon by adding some cement to it. 12 parts of earth, 4 of cow dung, and 1 of cement are the proportions experimented upon, by the author, and found to give satisfactory results.

(2) Coal tarring the surface. This should be done only after the walls have thoroughly dried. Otherwise, the coat of tar will come off in the form of scales, by the sweat of the wall surface. The tar should be boiled and made thin. To this may be added some powdered dry pith ( coal tar ) while being, boiled and when of the proper consistency, should be evenly applied while hot, with a brush. This remedy is fairly effective and is good also from the sanitary point of view. But several people do not like the dark surface, besides, it absorbs heat. To remedy this defect, two or three coats of white wash may be applied on it when the tar has thoroughly dried.

(3) The following is recommended by the U. S. Bureau of Standards in abstract No. 1806 issued by the Building Research Station, Garston, near Watford, Herts :—

"Make a solution of 12 oz. of paraffin wax in one gallon of gasolene ( petrol ). The melting point of the wax should be above the highest

summer temperature of the walls and the solution should be applied when the wall is dry and warm."

(4) The simplest and perhaps the cheapest recipe, which the writer has experimented upon and found most successful, is, to prepare a sort of paint by mixing ordinary 'white' or chopan earth in boiled linseed oil, of the proper consistency, so that it can be easily applied with an ordinary brush. This has the special advantage that all the materials are easily obtainable and the process is very simple. If necessary some colouring pigment may be used; instead of complex colours obtainable in the market, it is best to use '*geru*' or red earth, or iron oxide '*Hurmuz*,' Multan (*peeli*) *mitti*, or yellow ochre etc. found cheap and in abundance in nature.

(5) Another simple recipe is, to slake fresh lime first partly with milk (say 5%) and then with water, and mix it with linseed oil, or in fact with any oil. To this should be added 2% common salt (by weight of the quantity of dry lime). It would be found that a sort of paste is formed which may be thinned properly by adding water and applied with a brush.

(6) The usual remedy of applying rough cast plaster is also good. For this the surface may be well indented very closely by an edged

iron or wooden instrument, while still wet, and when it is dry it should be scrubbed with a stiff coir brush to remove all loose earth, then watered, and roughcast cement plaster about ¾ in. to 1 in. thick consisting three parts of sand to one of cement may be screeded or dashed on the wall surface so as to spread evenly. Cement colour looks quite well but if desired some pigment may be mixed with it.

## 6. WATTLE AND DAUB WALLS.

In districts close to forest areas, bullies (round rafters) of teak or other good timber are available at a cheap rate and material for lath, such as bamboos, reeds, or straight and thin branches of certain trees which are strong and tough, is also to be found in abundance. It would be very cheap at such places to construct a frame work of bullies (round rafters) and for the walls, a sort of wattle or rough trellis of the reeds or split bamboos may be made and thickly plastered with mud on both the sides. This could be further improved if the wattle is nailed in double rows on both sides of the bullies and moist earth rammed between them. If this is done, heat can be effectually shut out. If split bamboos are used, a precaution to lay them in such a way that the glazed side is inside, is necessary, otherwise, mud plaster will

not stick to it. The strength and the life of the plaster can be considerably increased if a mixture in the proportions of 12 of earth, 4 of cow dung and 1 of cement, is made and the plastered surface leeped with it.

This sort of wall construction is subject to the attack of white ants. Especially if bamboos are used the wall must be renewed every third or fourth year.

## 7. FLAG STONE LINED WALLS.

Another suggestion for cool walling which is cheap, is useful in districts where thin paving slabs of stone such as Shahabad, Tandur, Kadappa, in the Deccan and South India, or Katni, Rajputana, Chamba, or Rewari, in Central and Northern India, are sold at a very cheap rate. A framed structure of teak bullies with roof either flat or pent, supported on vertical posts may be constructed. The intermediate spaces between the posts, may be filled with a wall of sun-dried bricks on the inside and the above-mentioned slabs on the outside, or the exposed surface. They should be laid erect on edge one above the other, filling the joint with lime, or better still, with cement mortar. If the slabs are 1½ in. thick and are laid perfectly in plumb, and if, as an additional safety, iron clamps with diamond shaped pieces

of thin sheet, just to support the four corners of slabs on the face and a tail piece embedded in sun-dried bricks are used as shown in fig. 25 & 26 there is absolutely no apprehension of their

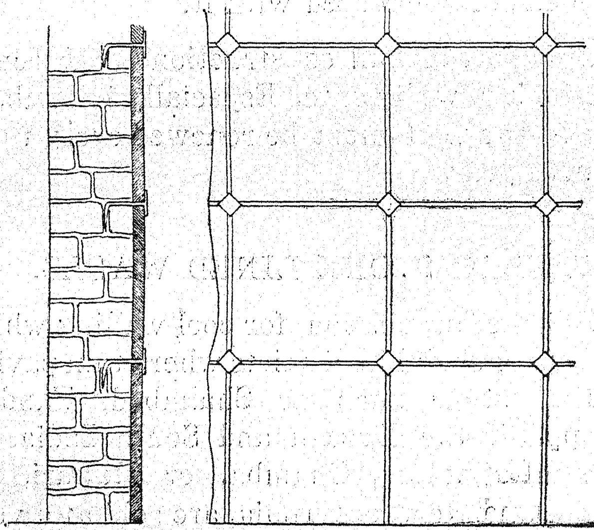


Fig. 25, cross section and 26 elevation

ever being dislocated. They will stand any rain and are bound to remain cool. If slabs are very cheap they may be lined on both the sides, and moist earth packed in between them, as the work progresses.

One often sees glazed tiles fixed in this manner to line the wooden walls of lavatories in 2nd class railway compartments, where they use brass clamps at corners and nail them into the woodwork behind. The above suggestion is based on the same principle.

If the diamond shaped heads of iron clamps are fixed in cement mortar and painted from outside, not only will they remain permanently in position unaffected by rust, but they will give in addition, a decorative effect to the wall surface.

## 8. NO-FRANGO WALLS.

No-Frango is a novel method of re-inforced cement concrete construction, in which instead of steel bars, as in the ordinary reinforced concrete, hessian or jute fabric (used in preparing gunny bags) is the reinforcing material employed. It is invented by major J. H. de Waller of Dublin, who has taken a world patent for it. It has just recently been introduced as a cheap building material and remains yet to be tried by the criterion of time and use. But whosoever have experimented upon it, including the writer, are very enthusiastic about it, and if what the inventor claims for it as being fire-proof, water-proof, vermin-proof and also cheap and strong at the same time, it will provide the long cherished panacea for the middle and poor classes, more particularly in India, where on account of its elastic nature, it is more suitable to meet the stresses caused by the extremes of temperature. The method of building walls with it is described below.

The foundations should be filled and masonry laid up to the plinth as usual. On the top of the plinth vertical wooden posts, or studs as they are called, say 3 in. by 4 in. in the walls which support weight of the upper floors and roof, and 2 in. by 3 in. in walls which serve merely as partitions may be erected, spaced at 3 to 4 ft. apart. It is desirable to give a coat of hot coal tar on them and to fix their bases in cement concrete blocks either pre-cast with holes in their centres to receive the bottom ends of the posts, or laid in situ. If the house is to have but a ground floor only, a wooden wall-plate 3 in. by 4 in. may be fixed on the tops of the posts to which the rafters of the roof may be nailed. The reinforcing fabric of hessian which should be, if possible, of special make, with open mesh of at least ¼ in., should be tacked to the posts at one end and stretched tightly and fixed to all the remaining posts also by means of tacks. The jute strands of the fabric should be, as far as possible, straight, that is, not much twisted. The fabric that comes directly from looms without passing through rollers or undergoing the callendering or sizing process, is the best. The test of this is, that it should present a hairy, coarse texture. The idea is, that in the interest of maximum strength the fabric should be as thoroughly impregnated as possible, with the cement grout which is to be applied to it. Too

much twisting and sizing leads to bad impregnation of the strands by cement. The stretched fibre should then be thoroughly soaked with water and while still wet a grout prepared with one part of cement and two of fine sand mixed in water should be applied to it, by means of a brush, both on the inside and the outside of the fabric, surrounding the outer surface of the posts. While this grouting coat is still fresh, cement mortar, consisting of one part of cement and 3 of coarse sand, should be screeded against the wall surface with a mason's trowel, to form a key to the plaster to be applied to it later on. Then 2 in. wire nails should be driven into the posts at random and left projecting ¾ in. beyond the surface just to hold the layer of plaster, which should be commenced as soon as the mortar already screeded is sufficiently hardened. This plaster should be in two layers; the first about ½ in. thick, with 3 parts of coarse sand and 1 of cement, and when this has sufficiently set, another of equal thickness, with mortar of the same proportions of cement and sand, but the latter should be slightly finer. The inside of the fabric should be also plastered but it is not necessary to give two renderings; only one of about ⅜ to ½ in. thickness is sufficient and need not also be made smooth.

When this is done fabric may be similarly fixed on the inside of the posts also, to form a

hollow space between the two fabrics. The processes of soaking with water, grouting and plastering should be repeated as in the case of the outer fabric, the only difference being that it is not possible to plaster both the surfaces of the inner fabric.

If insulation from heat is to be aimed at, it is necessary to seal the cavity, of whatever thickness, between the coverings of fabric. Generally a single cavity is sufficient, but in countries subject to extremes of climate it is possible to attain any degree of insulation by providing two or more sealed cavities. It is also possible to leave a cavity of 9 inches to one foot thickness and fill it with earth moderately rammed such as was suggested for a form of walling with a lining of thin paving slabs.

Cavities in walls not only prevent heat but also damp from outside. Walls with a sealed cavity of even ¼ of an inch have proved successful.

No-Frango walls have a special advantage viz., that they are rat proof.

Many houses have been built in Ireland, after this fashion with not only walls, but even floors, stair cases and roofs of No-frango construction, and have been giving perfect satisfaction these 5/6 years. The method of building floors and roof has been described later on in this treatise.

# PROTECTION AGAINST RATS AND WHITE ANTS.

Rats are a distinct danger to health as they are carriers of fleas, which often bear germs of plague. They, especially the bandicoot variety, are particularly to be guarded against, in houses with mud walls and murum or mud floors, because, they burrow under them and dig tunnels which often affect their stability. Their work in this respect is made easy, by damp, if present in the walls, because, it causes earth to lose cohesion, and therefore, the latter comes out easily at the slightest effort on the part of the rat. Thirdly, they eat out corn and other foodstuffs and even more important than this is the fact, that they cause a greater loss by doing damage to it. Hence, special safe-guards have to be taken to prevent them from harbouring in the neighbourhood of the house. If we make a careful study of their habits, we find that they make their abodes either underground under walls or floors, or in the roof, and that for their underground habitation they make holes by burrowing at the junction of the walls with the floors. This gives us some clue to work on some definite lines. A few alternative suggestions are made below :—

(1) The floors may be made of lime concrete. A layer 3 inches in thickness of stone metal, or brick-bats-and-gravel concrete rammed hard, will suffice, and this can be done at a very small cost. While still wet, if a dry mixture of two parts of very fine sand, and one of cement, is very sparingly sprinkled to form a layer, say, $\frac{1}{32}$ of an inch thick and the surface polished with a mason's trowel, a very durable and decent floor is formed. In addition to this, the walls on the inner side may be lined at their junction with the floor with flooring slabs or slates. Even the thinnest slabs would do. The slates may be one foot in width and may be so laid in lime mortar that about 3 or 4 inches go below the floor, and 8 or 9 in. remain above it, as shown in the marginal sketch (fig. 27) The concrete flooring and slate or slab skirting effectually preclude the harbouring of the rats under the ground surface. If slabs are costly, lime or cement plaster 1 in. thick may be laid instead of 1 ft. skirting.

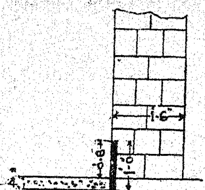



Fig. 27

Second suggestion is, to insert galvanised wire gauze netting 1 in. mesh about ¾ to 1 in. below surface at the junction of the floor and wall on the inner side. This sort of wire netting is usually employed round tennis courts,

on which creepers of luxuriant foliage usually trail, and can be had of 3 ft. width very cheaply. It should be bent at right angles and 18 inches should be laid flat horizontally into the floor and 18 inches vertically into the wall plaster. If a rat tries to burrow out a hole, he can go as far as this netting, against which, however, he is helpless.

(3) The third is an ingenious method and requires to be tried. It is this: ordinary mud used for plaster should be mixed with finely powdered glass or hard flint and used as a material for plastering the lower one foot of walls, and similarly powdered glass should be used in concrete for surfacing one foot near the edge of the flooring. If the powder is fine and if a smooth surface is made by polishing it with a trowel, there is no fear of getting one's fingers cut or scratched if one happens to rub them against it. However, to the rat it presents a distinct danger. Because no sooner it begins to burrow out with its teeth, nasty cuts and scratches to the tongue are sure to be made, which would cause it to desist from the attempt.

For preventing rats harbouring in the roof it is comparatively easy to construct such roofs as would block their passage to the cavity under the roof.

Another source of danger to which mud houses are liable is that from termites or white

ants. All timbers except teak, and perhaps one or two others, are attacked by them.

The remedies consist mostly of the preventive measures which are given below :—

At the time of clearing site, and before building operations are commenced a careful search should be made and any evidence of white ants should be removed by digging out their nests and destroying the queen ants at bottom, and grubbing up old tree trunks showing the slightest indications of their activities.

In places where the trouble is apprehended most, teak alone should be used, even if it costs a little more. Or, whenever possible R. C. C. (re-inforced cement concrete) work should be substituted, e. g. for door frames, wall plates, posts etc. It is even cheaper than timber.

Timber should be used only in exposed situations. White ants do not like their activities being watched and interfered with. Hence, they prefer dark, seclued, damp places where their lonely activities are least likely to be interrupted.

Posts, door frames and such other members of the structure which usually have to touch the ground should be provided with stone or concrete heels to avoid direct contact with

ground, and sides of door frames, wall plates etc. which have to be partly or wholly embedded in masonry should be given a coat of hot coal-tar before being put in position. Coal-tar contains 30 to 40 p. c. of creosote which is an excellent ant-destroyer. Hence, if very hot and thin coal-tar is applied, the creosote is absorbed by the pores of the timber, which makes it resist their attack.

Only the absolutely dry and well seasoned timbers should be used. All sources of damp should be vigilantly watched and precautions taken to remedy them promptly.

Timbers in situations exposed to sun and rain should be treated with some preservative paint or simple boiled linseed oil. Crude oil also is cheap and effective but has to be applied every year.

# DOORS.

Doors are unavoidable, although they form one of the costly items in an estimate of a building. A teak door of the minimum size, viz. 2½ ft. by 6 ft. even if of plain design, costs Rs. 30 at the rate of Rs. 2/- per sq. ft. Besides, it necessarily requires either an arch or a lintel. If the latter be of R. C. C. which is much cheaper than wood, another amount of Rs. 10/- has to be added. Thus a single door costs Rs. 40.

Hence, it is worth while to carefully scrutinise the plan of the proposed house and to see, if it is possible to reduce the number of doors by considering several alternatives of grouping of different rooms. Of course, convenience should never be subordinated or sacrificed to economy. Still very often too many unnecessary doors are provided. They not only increase the cost but also make the structure weak by leaving so many hollow spaces in the otherwise solid walls. They also interfere with the privacy inside the house.

Another way of effecting economy on this item, is to allot different widths to different doors according to the purpose of each. Thus the front door through which heavy pieces of furniture are likely to be carried in and out,

need be 3 ft. wide if not more, but doors in the inside partitions need scarcely be more than 2 ft. 6 inches wide. For doors of bath rooms and W. Cs. even 2 ft. width, will suffice.

The same may be said with regard to height; 6 ft. or 6½ ft. should be quite ample. Heights of 7 ft. or more are fit for public houses, such as schools, libraries, theatres etc.

A third source of economy is to provide one leaf only instead of two, wherever possible. There is a saving not only in wood and labour but also in hinges, tower-bolts etc. They are particularly suitable for bath rooms and W. Cs. and in partition walls. When placed at the end of a wall a single leaf door opens against the surface of the wall, and in this position it takes up the least space and obstructs the least. In a bed room it contributes to increase the privacy, because, when open, it conceals the view behind it.

Yet more room for economy will be found by making a door sufficiently strong to suit its particular purpose. In order to stress this point further to make it clear, let me ask a question "what is the function of a door?" The obvious reply is that the function is two-fold:—first, to protect the house-hold from thieves and unwelcome intruders, and the 2nd, to afford privacy. So far as these two objects

are concerned, we are perfectly justified in making all the doors in the exposed walls strong and stout, as we have been already doing all along. We should be equally justified in making the doors of the internal safe room, if any, strong and thief-proof. But the question remains:—"Where is the necessity of making all the internal doors also of uniform strength when their only purpose is to afford privacy between different rooms of the same house?" In fact, we indiscriminately make the interior doors also unnecessarily strong as if thieves are coming to break the doors, even of the kitchen and the lavatory with an axe! They need only be sufficiently strong to withstand the rough use to which they are often subjected.

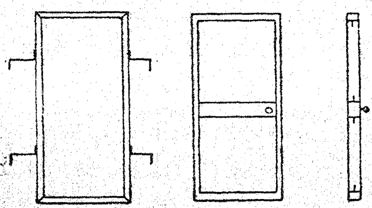
Light leaves would mean light frames also. No such stout frames of heavy scantling as 5 inches by 3 inches or 4 inches by 3 inches, would any more be required. Just 2 inches by 3 inches would be quite sufficient. That alone means a saving of 50 p. c. in the cost of the frames.

The ideal design should, in the writer's opinion, embody the following desiderata:—

The frame:-This may be of steel, either a T iron or angle iron of very thin section, such as that used for frames of steel spring beds. It

should be fixed by means of steel holdfasts rivetted to it, well anchored into the side walls, or of a thin section R. C. C. either precast or filled in situ by means of cement grouting.

The leaf:—The frame of the shutter should also be of steel—either of sheet, bent to form a hollow square section or angle iron. The intermediate panels which may be 2, 3 or 4 in number should be filled with water proof canvas with suitable designs printed on it, stretched and fixed to the inner edges of the panels by means of fillets screwed or bolted on to them as shown in the sketch. ( figs 28, 29 & 30 ) It is thus possible to choose the colour of the canvas, so as to conform to the general colour scheme of the room. The door might thus form a feature in the internal decoration. It is also an easy matter to clean the water proof canvas with a moist rag, and as for its wearing qualities, since even for camp lounges or easy chairs, canvas lasts for years together, there is no doubt about its lasting qualities for use in panels, where it is subjected to no stress.



Figs. 28, 29 & 30

Such shutters are likely to rattle and make a noise when opened or closed with a bang, to

stop which, the frame may be lined with felt, or fillets of hard rubber, fibre, or lead, may be fixed at 3 or 4 places as is usually done on the window frames of compartments of railway carriages.

A general line on which the design might be made, has been indicated here. It is upto the manufacturers to perfect it and offer it at a minimum cost. It should be possible to offer such a complete door with frame for less than Rs 10. Such doors will have an additional advantage of being absolutely free from the risk of fire or of white ants and dry rot.

So long as such enterprising manufacturers may not be forth-coming, let us be content with one of the following means temporarily improvised.

A frame of 2 inches by 3 inches scantling of teak wood embedded in the wall as usual and shutters made of a frame of 3 inches by 1 inch Moulemein teak with intermediate panels filled with either of the following:—

(1) Cardboard with wall papers of designs pasted on to it.

(2) Thick canvas stretched and painted in suitable colour.

(3) Cement asbestos sheet. (4) Celotax (5) Gunny cloth stretched and painted with cement grout (No-frango) etc.

All these are very cheap, light, and durable materials.

Sills of door frames may be necessary for doors in exposed walls in order to keep off vermin; but if they are omitted in the case of all interior doors, not only would economy be effected, but obstructions would be removed and work of cleaning floors would be facilitated.

## WINDOWS.

Shutters and frames of all the inner windows can be made of lighter design as suggested for doors in the previous chapter. If iron bars are provided for windows, ordinarily there should be no fear of thieves. Hence, a cheaper design for shutters of the windows even in the exposed walls can be adopted. The usual scantling adopted for a window frame is 4 in. by 3 in. Some times 4 in. by 6 in. is also to be met with. For windows of the ordinary size suitable for cottages, even 3 in. by 3 in. should be quite sufficient.

It is very economical to have long and narrow windows in preference to low and wide ones. There are two reasons for this. First, that both the span and the thickness of the lintel is reduced— length, because, the window is narrow, and thickness, because, the span is small. Second, that if the window is high, say, almost touching the ceiling, there is very little weight to bear on the part of the lintel and hence, the section may be thin.

This arrangement of long and narrow windows is beneficial also from the sanitary point of view, because the air, made foul and hot by human respiration, rises to the top in a

room, and if outlets at this level are not provided, it cools down after some time, becomes heavy, and descends, to be breathed in again. Windows, opening almost to the bottom of the ceiling, provide such outlets and help in driving it out to be replaced by fresh air from outside.

Again, if the design of the elevation is somewhat suitably altered, such long and narrow windows would form also an architectural feature from an æsthetic point of view.

Another hint in the interest of economy may be given. It is this:—If a door and a window are combined together as shown in the

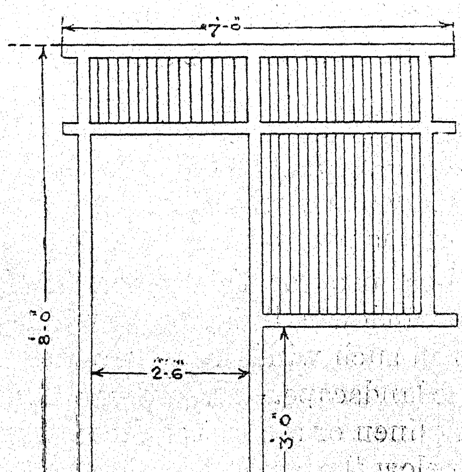



Fig. 31

above sketch (fig. 31) considerable saving is

effected. It is far more than what a casual observer may imagine it to be on the first thought. With the dimensions of the door and window shown in the sketch, there is a saving of 8 ft. length of wood; because not only one vertical side piece of the window, but five pieces projecting at corners i. e. in all about 3/4 of a cft. of wood and three ft. length, or 2·25 cft. of lintel are saved. This means a net saving of about 8 Rs., which is no small thing on one window.

One more suggestion for economy is, to utilise the space below the sill of a window for a cupboard. Ordinary cupboards require a lintel at top; but this particular cupboard does not; because, there is already a lintel at the top of the window. Thus a cupboard is formed for a small cost only in a space which otherwise would have not only been wasted, but filled with solid masonry, which, moreover, is saved if a cupboard is placed there.

Another use for this space in the wall below the window sill is, for providing a seat, especially in such windows as command a good view of the landscape. Even then, either a box for storing linen or a chest of drawers may be provided below the seat.

Very often money is unnecessarily wasted in providing elaborate ornamental projecting cornice below windows on the exposed side.

The object of the cornice is to allow the water collecting on the sill to drop away from the face of the wall. Hence, if a good slope is given and a drip moulding is provided, any cheap cornice of simple design either of cement concrete or Shahabad or other slabs, will do equally well.

In most parts of India, weather boards or window hoods, as they are often called, are required to prevent the wind-blown rain getting into the window openings. These act also as sun-shades in hot weather. If such weather boards are provided, shutters to the ventilators above the window proper, may be omitted. At most, some wire gauze netting to exclude birds, is quite sufficient.

A hint for economy in the annual maintenance and repairs charges of doors and windows, and in fact of any exposed wood employed in building construction, may not be out of place here. It will be found that doors and windows that have been once painted with a dark, or slate, or grey colour can be preserved for a long period by periodical coats of kerosene or at the most pure boiled linseed oil. They retain at the same time a good and neat appearance. If blue, green or other similar colours are used they soon fade away and if not renewed almost annually, the cottage presents an appearance of neglect.

Another means of reducing the bill on account of doors and windows is to cast their frames with cement concrete in a mould specially prepared. The section need not exceed the usual one of timber, viz. 4″ × 3″ and one rod of steel, ½″ in diam., should suffice for the re-in-forcement. This sort of frame costs about Rs. 2/- per cft. as compared with Rs. 5½ per cft. of teak wood frame. Besides, it is free from the danger of fire and attack of white ants. A difficulty in respect of fixing hinges for shutters, by means of screws in the above mentioned concrete frame is likely to be experienced. But if hollow spaces are left in the frame while moulding at the places of hinges, by inserting wooden plugs and if these hollows are subsequently filled with concrete made of 4 to 6 parts of screened coal ashes and one of cement, hinges can be fixed very firmly in it by means of ordinary screws as if in a wooden frame.

---

# CUPBOARDS

Cupboards ought to be regarded as a fairly good investment, especially in small cottages. Because, not only are they comparatively much cheaper than movable wardrobes, but they cause in addition, a saving in space and are free from the dust and dirt which usually accumulates below and behind the movable almyrah. Therefore, no corner or recess under the roof should be wasted, but turned into cupboards with shutters of whatsoever cheap material, one may like to choose.

Even in earth walls excellent cupboards, safe enough for storing even valuables, can be built, if they are lined on the inside with plain G. I. sheeting or Shahabad slabs, even of thinnest section available, whichever is cheaper.

It is worth mentioning here, that very often shelves of Shahabad or similar paving stones prove to be cheaper than wooden planks, which are, in most cases, used in cupboards. Teak planks, one in. thick even at so cheap a rate as Rs. 6/- per cft. including planing, fixing, oiling, etc. cost 8 annas per sq. ft.; whereas, Shahabad slabs at 10 Rs. per 100 sq. ft. cost about 1½ anna per sq. ft. i. e. they are 7 times as cheap. If, for rounding the

edges of the latter for the sake of appearance, one anna more per sq. ft. is added, the rate of 2½ annas is only 25 p. c. of that for teak planks.

The slabs have the additional advantage that they form one piece without joint, whereas, teak boards, wide enough to cover the full depths of the cupboards, are scarcely available. The stone slabs are, again, absolutely free from the danger of destructive white ants and fire.

With stone slabs, however, the width of the cupboard is restricted to 2½ ft. because 3½ or 4 ft, long slabs, though not quite unusual, are not easily obtainable. The standard length is 3 ft. out of which, three in. on either side, go for the ledge in the wall.

Remarks made about the light and cheap designs of shutters for doors in a previous chapter, apply with full force to cupboards also.

Provision of one or two small underground cupboards at suitable places add considerably to the convenience at a small extra expense. They are like miniature cellars and should have lining of stone slabs or cement plaster at bottom and sides, and wooden frames at top to which are hinged planked shutters, flush with the floor surface, so that, the top can be used as a part of the floor. The economical width of such cellars is 2½ ft. to 3 ft. so that, one inch boards can be used for shutters. If

such cupboards are placed against or partly in the exposed wall, it is possible to provide light and ventilation from outside below the plinth by means of 6 in. glazed earthenware pipe with fine wire-gauze at the end to exclude vermin.

# PARTITION WALLS.

The main function of a partition wall is to divide one large room into two or more smaller ones, which is required for the sake of privacy. Privacy is of two kinds–one, which is required in respect of sight and the other in respect of sound. It is a simple thing to provide for the first. Even a cloth screen is sometimes sufficient. But it is very difficult to make a perfectly sound-proof partition. A feeling of privacy in respect of sound is one of the factors which go to make a house comfortable. A thin partition of plain galvanised iron sheet or a frame work of split bamboos, battens or wattle plastered over, to serve as partitions scarcely afford any more privacy than the paper walls of a Japanese house.

In rural districts where space is not much restricted, the cheapest partition which is also sound proof, is one, built with Sun-dried bricks. A thickness of one foot is sufficient. Earth is a far better insulator of sound than stone or brick. Another advantage of such partition walls is, that it is possible to provide plenty of cupboard space in them. This advantage more than counter-balances the apparent waste of space.

In order to be really sound-proof, a partition wall must be carried up to the ceiling, whether flat or sloping. Above the height of the horizontal ceiling level, it may be made thinner for economy.

In places where space is very much restricted, thin partitions of No-frango, described in the previous chapter, can be built at a cheap rate. Air is comparatively a better insulator of sound than stone and brick and as the cavity between the two sides of the No-frango partition is occupied by air, the partition, even though thin, is rendered sound-proof. If it is desired to make it still more sound-proof, the cavity may be filled with felt or loose coir waste, or two thin air cavities may be formed.

Glass is a good insulating material, even better than air, hence, a partition of frosted glass, provides privacy of either kind. It is, however, more costly. Besides, it is liable to be broken every now and then.

# LINTELS

Economy in lintels can be effected, as already stated on page 121 by combining a door and a window together, so that the combined length is much less than that of the two separate pieces otherwise required.

Another way is to design high and narrow windows, which causes a reduction in the length and also in the thickness of the lintel.

As far as possible wooden lintels should not be used. For, not only are they costly, but, if once affected by dry rot or eaten out by white ants, it is both troublesome and expensive to replace them in that position. For stables, barns and other structures of minor importance, however, economy can be effected by using roughly squared round logs of hard wood instead of cut scantlings, with quarter cut pieces of bigger logs at ends. To prevent loose earth falling down through the joints, plain G. I. sheets should be bent to a form of a channel and nailed from below to the pieces of wood which should be generously treated with coal tar to prevent them from being attacked by dry rot or white ants.

The next cheap form of lintels is the flat brick arch. It is very simple in construction

and suitable for ordinary domestic buildings. It does not require any support or centering during construction, beyond a wooden plank at bottom. A radius equal to the breadth of the opening should be assumed and all joints made to converge to a common centre below. Only sound, well burnt bricks should be selected and they should be kept immersed in water for three hours. Mortar of good hydraulic lime should be used, and if it is not of good quality, a little cement, say, in the proportion of 7 of mortar to one of cement, should be mixed. For a breadth up to 3 ft., one brick or 9 in. thick arch is sufficient; for spans exceeding 3 ft., $13\frac{1}{2}$ in. thickness should be adopted. The arch should be kept covered with a moist gunny cloth for at least two weeks.

The next cheapest and simple in construction is a lintel of reinforced brick work which also does not require a support beyond a bottom plank as above. (Detailed instructions for this will he found in the author's "Modern Indian Houses and How to build them.")

Reinforced cement concrete lintels have now become very common. Instructions for preparing them also will be found in the above mentioned book. In the interest of economy, it is worth mentioning here, that if the walls are solidly founded on murum or rock, for spans upto 3 ft. there is no need of the reinforcing

steel bars if the lintls are 6 in. thick, and if bars are used, a thickness of 3 or 4 in. is quite sufficient for lintels over spans upto 4 ft.

Brick arches are comparatively much costlier and do not fit in with walls with mud mortar.

Where stone slabs are available at a cheap rate, the thickness of the stone lintel may be adopted according to the rough rule : to allow one in for every foot of span, plus one in.. Thus for a 4 ft. span thickness of 5 in. is sufficient.

A mistake is commonly made of building an arch over door or window openings close to the end walls. The result is, that the end walls are thrust out of the plumb line by the load of the arches, tending to stretch outwards and a crack is formed. The best plan is to provide flat lintels over such openings, and if arches are at all required for the sake of uniformity, a tie at springing, of say 2 in. by 1/4 inch flat iron, well anchored and countersunk in the wall, should be used.

# STAIRCASE.

No part of the house requires such a thought and careful attention in designing, as does the staircase. Its position governs and modifies the arrangement of the rest of the house. But unfortunately this matter of utmost importance is never prethought in India and in most cases is postponed to be decided at the last moment. It is then squeezed in somewhere into a verandah in a narrow space, and with winding steps, with such a steep ascent that to climb it, is an acrobatic feat. In most cases it is barely 24 to 27 in. in width. It ought surely to be kept in mind that people who build the house for their own residence, cannot escape old age, sickness and infirmity some time in their life, and that it is only then, the folly of having constructed a steep and narrow staircase would be realised.

The ideal position for a staircase should be such as will allow it to be approached from every important room independently through a lobby, however small.

The details of the service requirements of a properly designed staircase, have been dealt with at great length in the auther's "Modern

Indian Houses and How to build them" and it is not necessary to repeat them here.

It is a common practice to build the staircase of wood. Because, it can be made to look as elegant as required and there are also other conveniences in it. But it costs a good deal, particularly for labour, and entails the potential danger of catching fire.

A very simple, cheap and fire-proof staircase suitable for cottages is described below:—Take two pieces of rolled steel joists 4 in. by 1 ¾ in. weighing 5 lbs. per foot of length, of the required length of the slanting staircase. This should be previously calculated according to the instructions given in the author's book referred to above. Place them in position at the proper distance apart equal to the desired width of the staircase.

Their ends at bottom should be securely fixed in cement concrete and the tops also either bent a little and buried in cement concrete, or fastened to the floor in any other way. Take a piece of T iron, 3 in. by 3 in. by ⅜ in. thick, weighing 7·21 lbs. per ft., of the same length, and place it mid-way between the joists, with the T–flange pointed upwards. Thus if the staircase is to be 3 ft. wide there will be two joists at the ends and the T between them, leaving between flanges of the T and

either joist, a space of 18″ width. Cover this space by laying Shahabad or other paving slabs $1\frac{1}{2}$ in. thick with one side resting on the flange of the T iron and the other on the inner flange of the joists from bottom to top as shown in Fig. No. 32. The joints should be filled with cement mortar and when this is

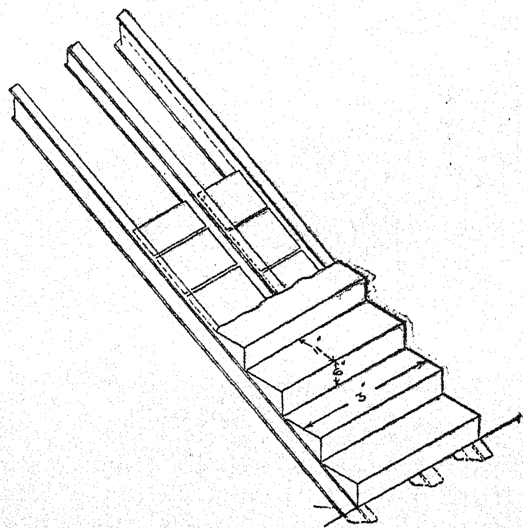


Fig. 32

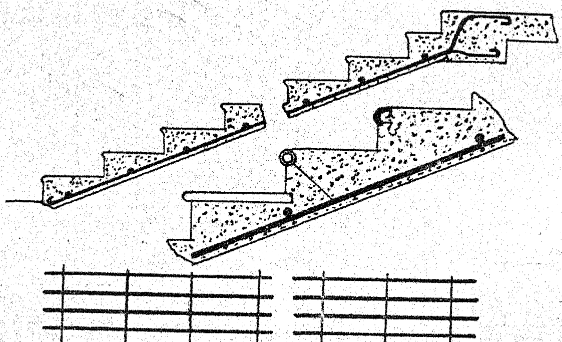
done, start laying brick-work in lime to form regular steps from the bottom. On the top of each step may be laid a wooden plank or a stone slab with its front edge left projecting half an inch. If stone stabs are not available at a cheap rate to cover the space between the joists and T iron, expanded metal sheet of the necessary width may be fixed by means of

bolts, to the joists and plastered on both sides with cement mortar to form a slab about 1 in. thick. This makes a cheap, light, sound-proof, and fire-proof staircase.

The following is a very simple method of constructing a reinforced cement concrete staircase, which does not require much skill, and hence, can be built by any cottage builder without expert advice. The joists and T iron, used in the above staircase, can also be dispensed with in this case.

Take 5 pieces of ½ in. round iron bars of the necessary length, and bend their ends as shown in the sketch Fig. No. 33 If bars of the necessary length are not available in the market join

Figs.



33

34

35

ends of two bars in such a way that they overlap at least 9 in., and tie them together by means of a wire. Place the rods side by side in the slanting position of the staircase at

equal distance apart, so that they cover the width of the proposed staircase. Bind them by 6 or 7 cross pieces of 3/8 inch round bar, and of length equal to the width of the staircase, by means of a thin wire at the points where they cross the long bars. When this is done erect some sort of boxing below the bottom and sides of the iron frame placed as above in position, so that a space of one half inch remains at bottom and both sides, between the frame and the boarding of the box. Pour cement concrete prepared in the usual proportions of 1 of cement, 2 of sand, and 4 of broken metal, the latter below one inch in size, to make a slab of 5 in. thickness. On this lay brick work in lime to form regular steps.

If it is desired to form the entire staircase of one homogeneous mass of concrete, the sides of the box should have regular steps cut into it. With these and pieces of deal boarding nailed to them to form boxing for each step, it is quite easy to cast the entire staircase with steps also in concrete. There is no necessity of any reinforcing bars in each individual step.

In order to protect the edges of the concrete steps against being knocked off, insert either pieces of 3/4 in. pipe, or brass castings, and bind them to the rods by wire before pouring concrete, or lay rounded edged flag stones on top of concrete. See Fig 34.

## FLOORING SUSPENDED

The usual form of wooden flooring almost universally in vogue, in towns and villages, is not only uneconomical, but it is liable to be easily gutted if the building accidentally catches fire. Besides, it involves a lot of labour.

In the author's book "Modern Indian Houses and How to build them" nine different types of flooring have been dealt with. It is proposed to describe here a few cheap ones among them, which are also fire-proof.

As a preliminary to starting the work of flooring it is necessary to take a precaution. If the walls which are to support the flooring are built with frames embedded in them (see page 52) i. e. if there are vertical posts and wall plates on their top to support the flooring, it is all right; if on the other hand, the walls are solid and of brick or stone in mud, it is desirable to cover their top with Shahabad or other paving stones not less than $1\frac{1}{2}''$ thick, in order to distribute the presure of the floor evenly on the walls. If such paving stones are costly lay cement concrete 2 in. thick instead.

Then place on the top of the walls thus prepared, rolled steel joists 4 in. by $1\frac{3}{4}$ inch

weighing 5 lbs. per foot of length, if the span does not exceed 12 ft., or $4\frac{3}{4}$ in. by $1\frac{3}{4}$ in. weighing $6\frac{1}{2}$ lbs., if it exceeds 12 ft., but is less than 14 ft.; they should be spaced 12 inches apart centre to the centre (see Fig.36.) Give a coat or two of bitumen or hot coal tar to the joists be-

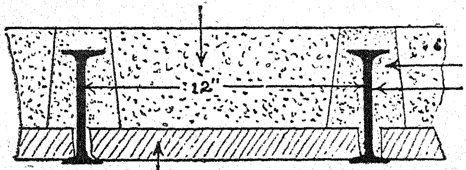



Fig. 36

fore laying them in position. Then, if paving slabs $1\frac{1}{2}$ inch thick are available at a rate of Rs. 8 to 10 per 100 sq. ft. insert pieces of them one foot wide from one end. If a ledge of ½ inch is obtained on the flanges of the joists, it is sufficient Fill the joists with cement mortar and fill the spaces above the slabs upto the top of the joists with anything light, say, broken pieces of burnt brick, coal clinker, murum etc. and ram it with a moderate force. On the top of this construct any sort of flooring of ¾ to one inch paving slabs laid in lime mortar and cement pointed, or even simple murum flooring will do.

If the rate of the paving slabs exceeds 8 to 10 Rs. per 100 sq. ft., it would be economical to follow the instructions given below :—

Erect some sort of centering so that its upper surface is about ½" below the bottom

of the joists. A centering of corrugated iron sheets (even old sheets will do) is very cheap and convenient. The corrugations give it a stiffness, hence, the wooden supports placed below the sheet, need not be so very strong and close together. However, it is necessary to cover the corrugations with moist earth to make a flat surface. Then prepare cement concrete with 5 parts of gravel, $2\frac{1}{2}$ of sand and one of cement and dash it against the sides of the joists to give them a wedged shape, $2\frac{1}{2}$ in. wide at top and $4\frac{1}{2}$ in. at bottom as shown in the sketch Fig. No. 37. When this sets, in about six hours,

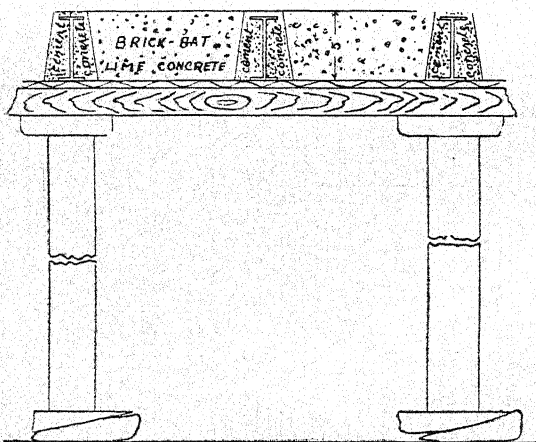



Fig. 37

prepare lime concrete with broken brick bats or screened boiler slag 3 parts, sand 1 part,

and lime mortar 1 part, and put it evenly upto the top of the joists and ram well.

After about a week remove the centering of c. i. sheets from the bottom and place it below the next portion. The object of putting cement concrete against sides of joists is two-fold:—Firstly, that the alkalies in lime concrete speedily attack steel and cause it to rust rapidly, the cement concrete not only prevents their coming into contact with lime, but increases their strength in addition; and secondly, that the shape of wedge given with cement concrete makes them serve as abutments and prevents the intermediate mass of lime concrete from sliding down. The whole thing behaves like a flat arch between two joists.

This method is not only very cheap and simple but as it allows small portions to be done at a time, it is possible for even a small cottage builder to build a fire proof flooring with only 3 or 4 old C. I. sheets for the centering.

The floor should be kept moist for three weeks by covering it with wet grass. On the top of it construct Indian patent stone or lay Shahabad paving stones as may be desired.

Another cheap form of flooring described below is suitable for timber districts where hard wood is available at a cheap rate.

For this take scantlings of well seasoned timber 4 in. thick and saw them so as to cut wedge shaped long pieces 1½ inch at top and 3 to 4 in. at bottom as shown in the sketch. (Fig. 38). Treat them generously with two coats


Fig 38

of hot coal-tar and place them in position with centres 12 in. apart. At the bottom of the inter-mediate space, place some sort of boarding or C. I. sheet centering as described above. Then pour into the space above it slightly rich mixture of concrete formed of 2½ parts of broken bricks, one of sand, and one of lime mortar and ram it well. The centering can be removed in about 10 days.

The wedge shaped pieces should not be planed, but left as rough as possible which increases their adhesion and helps to make the floor stronger.

## NO-FRANGO FLOOR.

This type of floor is quite new and has so far not got the opportunity to stand the test of time, but deserves to be tried. If it is found

successful it will satisfactorily solve the problem of cheap, semi-fire proof flooring suitable for cottages. Its exponents claim that a No-frango floor one inch thick over the supports and 1½ inch thick at the centre will carry a safe load of 112 lbs. per sq. foot with a spacing of joists no less than four feet apart.

For this type of flooring, wooden joists are more suitable. The room may be divided into several bays with beams preferably of rolled steel girders, and wooden joists may be fixed on them at right angles to the beams by means of dog spikes* at a distance of 12 in. between their centres. Hessian or jute fabric may be fixed by nails on a joist at one end and stretched and fixed by wire tacks on every intermediate joist. It should then be freely soaked with water and a coat of cement grout consisting of one of cement to two of fine sand, mixed in water applied to it with a brush on both sides. Before this dries up, cement and sand of all grades below 3/8 inch, should be first throughly mixed in a dry state, in the proportion of 1 to 3, then formed into a mortar with water and applied evenly on the upper surface of joists. The surface will naturally sink between the joists, which should be made level by adding mortar in the central portion. Thus, if the fabric is stretched well, and if a layer of 1½ in.

* A sort of nails.

is spread over joists the thickness of the central portion will be 2½ in. This catenarian form ( one of suspended chain ) is an ideal one for strength, because, the centre which has to bear more weight than the supports is thicker and therefore proportionately stronger. For extra strength two layers of hessian may be laid with intermediate grouting coat. The surface of this floor may be treated in any way desired i. e. either Indian Patent Stone ( described later on ) or asphalt, or any other covering may be formed on it.

The above floor would look uneven and ugly from below. To remedy this, a ceiling of some sort--even that of khaddar or gunny cloth stretched and tacked to the under surface of the joists may be made and white washed.

Next to these, comes the jack arch flooring, in simplicity and cheapness. For this, rolled steel joists are to be placed on the walls at suitable distances, say from 2½ ft. to 4½ ft.,

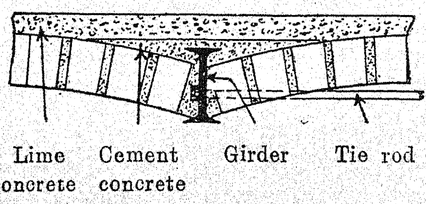



Fig. 39

and brick arches in lime 4½ in. thick, are to be built between as shown in Fig 39. These arches

can be built without any centering* and in fact, unless this is possible, the jack arch flooring loses its advantage of cheapness.

For the guidance of the layman sizes of steel girders and wooden joists for different spans for the two above methods are given in the subjoined table :—

**Table of steel girders and Wooden (teak) joists.**

| Span in ft. | Bay or the space between two girders. | Size of steel girder. | Weight of girder in lbs. per foot. | Size of Wooden joists. |
|---|---|---|---|---|
| | | in. × in. | | in. × in. |
| 8 | 6 | 5 × 3 | 11 | $2\frac{1}{2}$ × 4 |
| | 7 | 6 × 3 | 12 | 3 × 4 |
| | 8 | 6 × 3 | 12 | $2\frac{1}{2}$ × 5 |
| 10 | 6 | 6 × 3 | 12 | $2\frac{1}{2}$ × 4 |
| | 7 | 7 × 4 | 16 | 3 × 4 |
| | 8 | 7 × 4 | 16 | $2\frac{1}{2}$ × 5 |
| 12 | 6 | 7 × 4 | 16 | $2\frac{1}{2}$ × 4 |
| | 7 | 7 × 4 | 16 | 3 × 4 |
| | 8 | 7 × 4 | 16 | $2\frac{1}{2}$ × 5 |

---

* The process of doing this has been described in detail in the author's Modern Indian Houses and How to built them.

# PLASTERING

It is usual in India to plaster brick work in general with lime mortar on the outside. This is done for two reasons :—(1) that the quality of bricks manufactured in India, except perhaps in a few places, is bad. Hence, unless the outside surface is plastered, they present a bad appearance, (2) at many places the monsoon is severe, hence, unless the walls are plastered on the outside, moisture is sure to be driven into them by wind-blown rain and cause damp.

But plaster is very expensive both in initial cost and the subsequent maintenance and repairs. Hence, it would be advisable in the interest of economy, to avoid it wherever possible.

To obviate the difficulty due to reason (1) above, viz. to improve the appearance of bad bricks, plaster should not be necessary. Because, if a slightly greater attention is given to select good bricks for the face work and pointing is done a little more neatly, a far better decorative effect can be obtained than with plastering. If however, plastering is required for the second reason, viz, to make the exposed surface impervious to water, it cannot be

avoided. Still, economy can be effected in another way, viz, by using cheap bricks; even ground moulded country bricks will do, provided that they are strong and durable. There is a lot of difference in the rates of table-moulded bricks of standard size and ground-moulded country bricks. If the surface is to be covered under plaster, then why not use the cheap stuff if it is sufficiently strong ?

If it is found necessary to plaster the outside surface of walls, economy, at least in the renewal of colour washing, may be effected by using some cheap pigment of lasting colour in the plaster itself initially so that, it dries out to a pleasing colour, and omitting the annual colour or whitewash altogether. Multan *mitti* gives a buff colour, if some red ochre is mixed with it, a cream colour is obtained; lamp black gives a grey colour. All these colours are pleasing and lasting.

If walls are built of brick or stone in lime mortar, economy might be effected by omitting the plaster in certain rooms of the house, where it is really redundent e. g. in store room, fuel room, loft etc. It is also very difficult and expensive to maintain it in such rooms, because, there is every chance of its being damaged every now and then by something striking against it.

When a wall is one brick thick i. e. 9 in. wide it is possible to so build it with care that one of its faces is quite even. If then the latter is rubbed by a hard brick and white washed, no plastering is necessary on it. If a smooth surface is required, cream of lime may be daubed here and there against it and spread over the surface by rubbing it quickly with a piece of brick dipped in water, in which, some jagheri is dissolved, so as to form a plaster 1/8 in. thick or even less. This is very cheap and durable.

Mud plaster is cheap in initial cost and cheaper still in maintenance. It, furthermore, possesses the advantage that as the building grows old and the wall gets covered with many coats of colour and whitewash, it is a simple matter to scrape off the coats and make the surface smooth again by giving a hand wash of mud and cowdung mixed together. On the other hand, lime plaster if scraped, is damaged and cannot be made smooth again even at great pains and expense.

The proper way of plastering the inner surface of walls with mud is as follows :—Select proper earth; earth containing too much clay will cake and form cracks ; while that containing too much sand or loamy matter, will not stick properly. If earth found in natural state is not suitable, blending the two together in correct proportions will make it so.

It should then be screened through a 3/8 inch mesh sieve, so as to exclude bigger stones and lumps of earth, and be left to soak into water for at least 24 hours. Some people allow it to soak for a month, but unless the earth has salt in it the advantage is dubious. On the contrary, unless it is turned over and mixed with water every day and kept in a pulpy condition it is likely to form lumps which are difficult to break.

While mixing, cut straw should be freely added to it. Some people put some cowdung or droppings of horses crushed to powder, with advantage.

The surface to be plastered should be prepared by raking out Joints to give a hold or key to the plaster, and the mixture of the proper consistency should be evenly spread on the surface and worked with a wooden float.* After 24 hours, while it is slightly wet it should be tamped well with a wooden or metal edge; the dents should be as close together as possible.

The secret of success lies in this tamping. Even if a portion cakes and sounds hollow, the tamping will cause it to stick to the wall

---

* Float is an instrument consisting of a flat and smooth piece of wood used for planing and levelling plaster.

permanently again. This must be done in right time, once the inner skin of the plaster dries up, any amount of tamping is of no avail.

After tamping, a thin wash of cowdung is given and tamping done again at places where small cracks are seen to have developed. Then the final slightly thicker wash of cowdung and good chopan or white earth or better still, of sodiumised clay (please see page 30.) is applied by hand just to cover all the indentations made during the tamping process. After this the colour or the white wash may be applied.

The above is for plastering inner surfaces of walls. For outer or exposed surface, the same process is to be repeated till after the tamping. The final coats to be given after this, must be such, as would help the plaster to resist atmospheric influences. Hence, instead of a wash with mere cowdung and earth one with a mixture of 12 parts of sodiumised clay to 1 of cement, should be given to close the indentations. If the earth is specially made impervious by the process described on page 31 viz. by mixing salts with it and precipitating it in water excellent results would be obtained. In that case the cowdung may be altogether omitted. This makes the skin of the surface hard and non-absorbent, which, in consequence, wears

well even in rain. The above wash is very useful for walls of earth.

For making the exposed surface water-proof to resist a piercing rain and wind, recipes suggested on page 99 for water—proofing exposed surfaces of earth walls may be noted.

## FLOORING (GROUND).

If a house is not likely to be infested by rats, murum or earth floors, if properly done, are excellent. They are cheap, easily made, wear sufficiently long, and are easily maintained and repaired. They maintain an equable temperature i. e. they do not get cold in winter nor hot in summer, and hence, for Indian people who, in most cases walk bare footed, inside the house, they are very suitable. Some people condemn them as insanitary on the ground that they absorb water and that in order to maintain them properly, they have to be frequently coated with cowdung, which rots, stinks, and breeds millions of microbes.

To a certain extent this is true, but when all other factors are considered and it comes to choosing between two evils, the writer would be inclined to choose the lesser evil of murum or mud floors than that of any stone paving, imperfectly done.

In the houses of the poor, stones for paving, if used at all are laid, generally on top of murum instead of on concrete. The quality of the slabs and workmanship are far from satisfactory. Again, unlike in the houses of the well-to-do, the floors are subject to rough use.

As a consequence, the murum sub-layer soon sinks, the joints in the slabs open out and an uneven surface is formed. For proper sanitation the floors must be washed with copious water mixed with some disinfectant, at least twice a week. But in the houses of the poor, this is never done except once or twice during the year on ceremonial occasions or on certain holidays, when the whole house is cleaned as enjoined by religion; that, too, is done without any disinfectant and in most cases with a scanty supply of water. One can easily imagine what the process of washing and cleaning would be like, when the surface is rough and uneven, with several open joints, through which water must be soaking into the absorbent layer of murum or earth below! In fact the washing, instead of removing any dirt, multiplies it.

Besides, in certain orthodox sections of the Hindu community, even if a particle of food drops down, the ground is defiled, to sanctify which, comes a wash of cowdung! In the kitchen, where food is cooked and in the dining room, where it is served, local application of cowdung, is made several times a day, no matter what sort of a floor it is. It can be easily imagined to what extent, dirt must be sticking to the rough grained paving slabs, and inviting swarms of house flies—the dreadful enemy of human health!

From this point of view, murum or mud floors are preferable. They are easily made smooth and as such take the least quantity of cowdung and dry up again very speedily.

Constructing murum floors is a matter of common knowledge and experience. Still the salient points which ensure success are described below:—

## MURUM OR MUD FLOORS

All black earth, at least that in the portion one foot below the ground, should be removed and the surface should be filled with boulders of stone or brick clinker, packed together in a layer of six in. Above this, should be spread 6 in. of loose murum with coarser pieces at bottom and finer at top. On the top of this, a layer of powdery or flaky murum 1 inch thick should be spread. Then water should be freely sprinkled on the surface which should be rammed well at the same time. After this, copious water should be evenly spread until it stagnates and appears about $\frac{1}{4}$ inch at top. The surface should be roughly levelled and trampled under feet of workmen until the cream of murum rises to the top. It should then be left to itself for 12 hours and then rammed by means of a wooden rasp for two days, both in the morning and evening. After this a wash of cowdung about

$\frac{1}{16}$ inch thick should be given and the floor rammed again, once in the morning for two days. If it be summer time, it will be sufficiently dry by now, and will be ready to receive the final thin wash with 4 of cowdung, and 1 of cement mixed in water and applied evenly, and wiped clean from the surface by hand. If necessary, some lamp black may be added to it for the sake of appearance. The floor made in this way is very smooth, hard, and fairly impervious to water.

If the murum be earthy and very soft, sand may be very thinly sprinkled on the surface on the 3rd day and rammed well with a rasp. Instead of cement and cowdung, a coat of hot coal tar may be applied and polished with a mason's trowel. This makes it more impervious, but some people do not stand the smell for a few days. Before applying this coat, the floor must be thoroughly dry, otherwise the moisture of the surface might cause it to cake and peel off. Murum is available in Southern and part of Central India. In other places earth floors are made. The difference in constructing murum and earth floor is, that whereas water is freely used in murum floors, it is very sparingly done in the earth floors. If earth, as it comes from the pit, is moist, there is no need of watering it at all. It should be spread in 6 in. layers and rammed until very little impression is made by the heel of the boot; then a wash of

cowdung and cement should be given to it as above. While renewing earth floor, all the old earth must be removed and replaced by new. For murum floor, this is not necessary, the old murum lasts for 10 to 12 years.

## CONCRETE FLOOR.

In places where trouble, from rats burrowing under walls, is feared, floors of concrete may be done at a cheap cost. The surface below the concrete must be absolutely unsinkable, otherwise, cracks might result. Where stone is available at a cheap rate, the floor may be packed with boulders about 6 in. thick and upon them should be spread a lay[illegible] 6 in. of murum or gravel, which sho[illegible] at bottom watered and rammed. Upon th this, a layer of 3 in. of lime concrete prepared thick should be metal to 1 of unscreened sand, freely sprinkled and one of lime mortar and ra be ramm[illegible]d. Upon this should be sprinkled [illegible] con[illegible]ery lightly, dry mixture of 1 of cem[illegible]nt and [illegible] of fine sand through a sieve of fine mesh and immediately polished with a mason's trowel, so that the cream of lime on the top of concrete dries up and forms with the cement a hard skin layer. This must be done just at the proper hour. This sort of floor if done well, wears very well and is absolutely water-proof and rat-proof.

## INDIAN PATENT STONE.

This is a further improvement on the concrete floor. In order to ensure absolute freedom from cracks, the sub-layer must be made quite unsinkable with great care. Upon this is to be laid 3 to 4 in. of lime concrete as above and rammed for two days. Before this sets, lay on its top, a 3/4 inch layer of a mixture of 3 parts sand and gravel of all sizes below ½ inch and 1 part of cement, in water evenly laid and rammed at the same time by the mason's trowel, and as soon as it sets, that is, in about six hours, another half inch layer of slightly finer sand 2 parts, and cement 1 part, mixed first twice in a dry state and then twice again in water, should be applied and levelled with a wooden float. Colouring pigment, if necessary, should be added to this mixture and the surface polished with a trowel. A very smooth polish is harmful in both ways:—Firstly, the surface is liable to crack as a thin film of cream of cement rises to the top, and secondly, it becomes slippery.

To prevent the latter, lines crossing each other are drawn about ⅛ inch deep to show squares or diamonds, which also sets the floor off. If the surface is long and extensive, expansion joints are necessary. The floor is divided into rectangles by erecting either battens, 2″ by ½″, on edge or cardboard, and the

cement concrete is laid on both sides of it. When the latter sets and dries up, the battens or boards are removed and the space filled either with hot asphalt or coal tar upto $\frac{1}{2}$ inch below top, the space above which, is filled up with sand and the joint wiped off. In course of time the asphalt rises up and consolidates the loose sand. *

Another very cheap, durable, and water-proof flooring can be constructed in the following manner :—

Spread a layer of road metal about 3 in. deep. It does not matter, if the metal is slightly soft, but should not be murumy or earthy and liable to be crushed to powder under the strokes of a rammer. Consolidate it well in a dry state as is done for preparing roads so that all the pieces at top are interlocked together, and that, there are no loose pieces at the surface. When this is done, pour on it, hot coal tar just enough to form a layer of, say, $\frac{1}{10}$ of an inch. Sprinkle on this, a layer of fine sand free from earth. It should be just thick enough to cover the tarred surface i. e. about $\frac{1}{8}$ to $\frac{1}{4}$ inch thick. This should be rolled with a small stone or iron hand roller, or if the latter be not available, with a rammer

* Instructions in detail about this sort of flooring, have been given in the author's "Modern Indian Houses and How to Build them," especially regarding guarding against failures.

first lightly, and afterwards vigorously with a wooden rasp. The rasp should be so applied that the surface becomes smooth and even.

For the first month the surface smells of coal tar, which, to some people, is disagreeable. This sort of floor wears very long and, is perfectly satisfactory in every respect.

## NO-FRANGO FLOORS.

These are new to India. The writer has experimented on a small scale and found them to be successful. They are made in the following manner :—

As soon as the walls are raised upto the plinth level, the intermediate space is filled with loose earth, and a layer about 3/4 inch thick of loose gravel is spread at the top. Then with a heavy crow-bar, holes of $1\frac{1}{2}$ inch diameter, 18 in. deep are made in it, at a distance of $2\frac{1}{2}$ feet, both longitudinally and cross-wise. In these holes, cement concrete is poured and while it is wet, a wire nail $1\frac{1}{2}$ in. long, is inserted with $\frac{1}{2}$ inch left projecting above the top of the concrete. These are a sort of piles of concrete called, "Plunger Piles." Hessian or jute fabric is then stretched from outside of a wall on one side to the outside of the wall on the opposite side. The seams are made by overlapping the hessian 6 in. upon each other and sewing it, by means

of a thin wire. The projecting top of nails must come above through the hessian. The latter is then soaked freely with water and treated in the same manner, as described for walls on page 107 with a grouting coat, and then plastering. The fabric must be stretched well so that it does not sink much in the centre under weight. The surface is to be made level by adding more material in the hollows when wet. If the hessian is stretched properly, a depth of $1\frac{1}{4}$ inch on the top of the plunger pegs, and $2\frac{1}{2}$ inches in the middle, is sufficient, for obtaining a perfectly level surface. In course of time, the loose earth at bottom sinks down, leaving a cavity between the ground and the under-surface of the No-frango floor. This ensures protection from damp and white ants.

The surface may be either made smooth, as in the Indian Patent Stone floor, or treated with linoleum, asphalt or any other material or tiles.

# ROOF.

Roofs are of two types; one, flat and the other pent. The latter is also called pitched or sloping. On account of the extreme variations in temperature to which all parts of India, except the coastal region and hill stations, are subjected, flat roofs, unless very carefully and scientifically constructed, cannot be entirely relied upon in India. In coastal regions and hill stations also, though the temperature is equable, the proportion of the average rainfall is much greater than that on the plains and therefore, there is no less apprehension from leaky roofs than elsewhere. Besides, flat roofs necessarily require a parapet wall, which, if not constantly watched and kept neat and tidy, presents a squalid appearance.

If, however, a flat roof is rendered really watertight, it provides an extra accommodation for sitting on cool evenings or sleeping during nights in the hot season at a high level. But this advantage does not really count in rural districts where open space surrounding the house is unrestricted.

If a pent or pitched roof, on the other hand, leaks, it is easy to set it right. Besides it always looks elegant and presents a home-like appearance.

In cities and crowded towns it is the best policy to choose a mean i. e. to cover the greater part of a building with a pent roof and construct a terraced roof on the remaining part, so that, the advantage of a flat roof would be derived, and at the same time, the fear of leaks would be reduced.

It is often argued by the advocates of flat roofs that the latter keep the rooms under them cool, but this is doubtful; because, for affording a real protection from the heat of the sun, the thickness must be something like 12 in., which, no one ever adopts. The usual thickness given is from 4 in. in the case of R. C. C. roofs, to 9 in. in the concrete terraces or mud roofs. The degree of coolness afforded by this thickness, can be easily obtained from pent roofs, if a wooden ceiling is constructed and some air space is left between it and the tiles above.

On the contrary, a building with a flat roof on, is fully exposed to sun unlike that with a pitched roof, the projecting eaves of which afford a considerable real protection both from heat and rain and besides keep the building dry as the water from eaves flows away from it.

Let us take the pent roof first. Thatch is the cheapest material and if carefully laid in sufficient thickness, the roof gives an absolute protection from the sun and rain. But there

are two dis-advantages, which very much detract from its usefulness. The first is, that it possesses the potential danger of catching fire, and the second, that it absorbs rain-water which causes the straw to decay and give out foul gases.

Then come tiles, either half round or flat, which have been used from very old times. They, however, absorb heat and are liable to be broken by run-away monkeys, and have therefore to be turned and partly replaced by new ones every year. Besides, for country tiles which are heavy, rather substantial scantlings of timber have to be used, which go to increase the cost.

Mangalore pattern tiles are light and more durable, but they also absorb heat. Again, they are likely to be blown away by hurricane. To remedy this, wooden or other ceiling has to be constructed below them, which also serves to mitigate heat. A still further objection to their general use in small towns and villages, is, that the tiles are not locally manufactured, and therefore unless a sufficient stock of this breakable material is always maintained, as they are liable to be broken or blown away, great inconvenience is caused, until they are fetched from cities or large towns.

Slates, cement asbestos, and like sheets are utterly unsuitable for the hot climate of

India. Besides, they are liable to be broken and are even more difficult of replacement in upcountry places than Mangalore tiles. Their cost also is heavy and prohibitive.

The material most suitable is the corrugated iron sheets. They are light, very strong and durable. Although something has to be done to them to prevent them from being blown away by winds, and from absorbing and radiating heat of the sun, they are the most satisfactory as regards cheapness, durability, and the thorough protection, they afford from rain, if a sufficient slope is given to the roof.

Fortunately excellent sheets are now manufactured in India by the Tata Iron and Steel Co., and offered at the same rates as those of foreign manufacture.

For preventing heat radiating from the C.I. sheets, the following are some of the remedies:–

Colours play an important part in either absorbing or reflecting heat. Black colours absorb most, and white, least. But the latter causes a glare to the eye. Hence blending of some other colour in white so as to make it either grey or brown or chocolate is necessary. The latter matches with the colour of the bricks or tiles and is pleasing to the eye.

Ordinary white wash, made of freshly slaked fat lime and water, in which 15 p. c. of

boiled linseed oil is mixed, forms an excellent wash for application to the C. I. sheets. It not only remains permanent, but reflects sun's heat and also protects the sheet from corrosion to which they are very susceptible, particularly near sea coasts on account of the sea-borne breeze, in which particles of salt are dissolved.

Another remedy for the preservation of the C. I. sheets from corrosion and mitigating radiation, is to apply a thin coat of neat cement with a brush preferably in the evening so as to allow it a full opportunity to set slowly in the cool weather during night time. After about a week, another thin wash may again be similarly applied.

Other remedies for mitigating heat are to spread a grass matting on the top so as to leave an air space of about 3 in. between. This, however, harbours rats and the mat requires to be renewed every 2nd or 3rd year, otherwise, it rots, falls to powder, and obstructs the flow of rain-water by choking the channels in the corrugations.

Still another remedy is to cover the top with bamboo matting, which is an excellent reflector of heat. If an arrangement is made to sprinkle water on the matting at intervals so as to keep it moist, radiation is effectually prevented.

Wooden ceiling fixed below the C. I. sheets so as to leave an air space of at least 3 in. is also a good remedy to prevent radiation of heat.

A few remedies for preventing the roof from being blown away are suggested below:—

The simplest and most rational is, to provide sufficient apertures just below the eaves on both sides of the house so that the wind should enter through them on one side and pass through those on the other. Generally what happens is, that the wind striking against the wall changes its direction and applies a lifting force to the projecting eaves. Once the eaves are lifted up, the whole roof is blown away. If such apertures are provided, ordinary precautions taken against the roof being blown away, are sufficient.

Another way is to lay tiles over the roof just for weighting it. But if 2″ by 1 inch battens from ridge to eaves, 2½ ft. apart, and above them at right angles battens as usual, are fixed to them across and Mangalore tiles laid over the latter, not only are the sheets weighted but the 3 inches air space provided between, serves to reduce the radiation to a great extent. There is one objection to this method, viz. that the hollow space harbours rats. But if brick bats are laid in cement mortar on top of sheets near the eaves and end tiles fixed on them there remains no space for rats to enter.

If country tiles are to be used for weighting, give a generous coat of coal tar to the roof surface, spread hay or straw on it and lay the country tiles as usual. The tiles at ends must be securely pressed by means of a long piece of flat iron, or teak batten, bolted to the sheets to prevent the tiles from sliding down the slippery surface of the straw. This very effectually prevents radiation of heat.

There is, again, the usual elaborate method of fastening down the sheets at the eaves and gables by continuous lengths of a steel flat or a steel wire rope fixed by bolts embedded in the masonry at about 4 to 6 feet intervals. These bolts should be 1½ ft. in length and anchored into the walls by means of 6 in. sq. iron plates.

Often times steel joists or angle irons are cheaper and more suitable as purlins under corrugated iron sheets on account of their property of resisting fire and white ants. In that case special steel wire bolts may be used, as shown in the sketch. (Figs. 40 to 42)

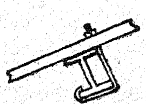


Fig. 40

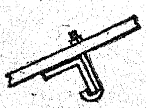


Fig. 41

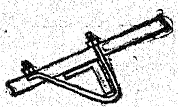


Fig. 42

It is necessary to punch the holes in the C. I. sheets neatly with a sharp cold chisel. Otherwise they are likely to be torn asunder

causing leaks. The carpenters who do this job, are generally very careless and must be vigilantly watched. Similarly they often fix the galvanised screws by hammering on their heads just to save their own labour. This makes them loose.

If some 2 in. of cement concrete is laid over the C. I. sheets, the roof is weighted against being blown away and in addition, the radiation of heat is reduced to a certain extent. If this is done, care should be taken to lay the concrete in the evening. Otherwise by the heat of the sun, it sets so quickly that ramming becomes impossible.

The second point to be noted is, that unless some sort of reinforcement is used on the top of the concrete just in the lengths, where the C. I. sheets are supported from below, cracks are sure to develop. To prevent this gauze wire netting even of 1 inch mesh in strips of 9 in. width, may be embedded about $\frac{1}{2}$ inch below the top of the concrete. The cracks are unimportant from the point of view of leakage or structural strength. But they form an eye sore.

## NO-FRANGO ROOF.

As a roofing material No-frango has great possibilities in tropical countries like India; because, on account of the elasticity it possesses, which is due to the hessian (jute) fabric

embedded in it, it is least susceptible to form cracks on account of the temperature stresses.

The construction of the framework is similar to that of the Mangalore tiles, the only difference being, that the battens required for the Mangalore tiles are not required for the No-frango roof.

Even a thinner section of rafters would do as the No-frango slab is not more than one inch thick, and is much lighter than Mangalore tiles. Hessian fabric, as wide as available, may be soaked in water and stretched from one end to the other, an overlap of 6 in. being given at the joints which should be stitched either with hessian twisted yarn, or thin steel wire. Instead of stretching the whole piece from one end to the other, better results are obtained, if the portion from one rafter to the another is stretched and fastened by means of tacks. This may, again, be soaked in water and a grouting coat of one of cement, and two of fine sand, should be applied by means of a brush. When this sets, but is still wet, the usual coat of cement and sand mixed in the proportion of 1 to 3 should be screeded on to it and the surface rendered smooth by means of a float. The surface is bound to be uneven showing ridges over the rafters and furrows between them. This is, however, an ideal condition, because so many channels for draining off rain-water are automatically formed.

It is necessary to take particular care in respect of watering the roofing slab in the tropics. Unlike ground or suspended floors it is exposed to sun. On account of the fabric being stretched well, the excess of water drains away and hence, if a special care is not exercised it may get quite dry before it sets and obtains sufficient strength. Saw-dust may be spread on the top to retain moisture.

This sort of roof would give a perfect protection from rain but not from heat. For the latter, wooden ceiling may be fixed on the under surface of the rafter so that an air space equal to the thickness of the rafters is obtained.

In Ireland they first lay boards for ceiling, upon them a layer of felt impregnated with bitumen, and on the top of the latter, No-frango slab is cast. The bitumenized felt serves two purposes:—Water-tightness and reasonable protection from heat, as felt is a non-conductor of heat. For Indian conditions, this would not be sufficient to prevent radiation of heat inside.

If flat roofs are to be constructed of No-frango they may be done just like the suspended floors described in the previous chapter. For additional strength, instead of one, two layers of hessian fabric may be laid. A good cross slope for draining off the water collected is absolutely necessary.

## SOME PRACTICAL POINTS AND HINTS FOR ECONOMY IN PITCHED ROOF.

1. A wall plate is supported by the wall below throughout its length and therefore, is not subjected to stresses like a beam. Its functions are firstly, to distribute the pressure of the roof uniformly on the wall and secondly, to make a junction between the roof and the walls below. Hence, they need not be of such heavy section as 4″ by 5″ or 4″ by 3″ as is commonly done. Even 2″ by 3″ will do. Concrete, stone, or wooden bed-plates will also serve the purpose equally well.

2. Instead of one heavy verandah post of, say, 6″ by 6″ if two pieces say, of 4″ by 3″ or even 4″ by 2″ are joined by cross pieces and latticing as shown in the sketch (Fig. 43) to form a compound pillar, not only is its strength increased, but they can either be spaced at longer distances apart or the depth of the post plate may be reduced. Such sort of pillars also look more elegant.

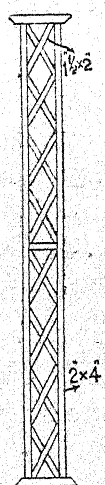


Fig. 43

3. It is unnecessary to plane timbers which are likely to remain hidden from view e. g. wall plates; and if a horizontal ceiling is constructed, all roof timbers may be left unplaned.

4. Alternative rough estimates should be made to see which of the two—horizontal or sloping ceiling, is cheaper. The horizontal ceiling looks well and is better for prevention of heat as it encloses more air space and also requires less boarding but heavy framework is required to suspend it.

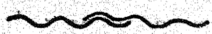
5. Ends of C. I. sheets should never be embedded in masonry.

6. Very often an oil paint does not stick to new C. I. sheets, or if applied it cracks and comes off in curly flakes. This should be remedied by washing the surface with washing soda or the paint should be applied after the sheets are exposed to weather for a few months.

7. If it is intended to cover the C.I. sheets with tiles, and if the latter are of good quality, considerable economy may be effected by over-lapping even half a corrugation as shown in the sketch. (Fig. 44). If no tiles are to be laid, then 1½ corrugation must over-lap. (Fig. 45).

Fig. 44

Fig. 45



The end over-lap must be 4 in. and if the slope of the roof is small, 6 inches.

8. Instead of lead washers, which are costly, if pieces of strong cloth soaked in asphalt are

wound round below screw heads to form washers, they are cheaper and more watertight.

## FLAT ROOF.

Unless perfectly water-proof materials like bitumen or asphalt are used at great cost. flat roofs cannot be expected to afford absolute protection in the hot climate of India. They necessarily require some sort of parapet wall and as the gutter collecting the rain water on its surface has to come behind them i. e. just on the top of the wall below, any small cracks —even hair cracks—in the gutter cause the water to descend directly into the wall below.

The merits and de-merits of the flat roof have been already discussed in the preceding chapter. There are various methods of constructing flat roofs, according to the climatic conditions, materials available, and the local practice of the different places. The cheapest form used, is that of round ballies nailed on to wooden beams to span the space across them, over which, are laid some sort of reeds or wattle or long twigs of trees, such as *Sarkand* or *Samalu* in Northern India, or *Karvi* or palm leaves in Southern India.

On the top of these is spread a 6 in. layer of stiff mud which is beaten hard; if the mud is not of earth which is non-absorbent, special

non-absorbent clay ( *White earth* ) is brought from a long distance and spread loosely in a layer of about 1 to 2 inches. The wattle is sometimes replaced by timber waste obtained from saw mills, which is nailed to the rafters.

At some places better class people use mild steel T pieces, which are inserted and laid in an inverted position one foot apart and special roofing tiles, 12 in. by 6 in. by 2 in. (usually) are laid on the flanges of the T pieces, and over these, mud and loose earth are spread as above.

The top surface of flat roofs must be suitably sloped, the exact degree depending upon the local circumstances, such as the rainfall, the quality of the clay available, and so on.

The watertightness of such roofs depends entirely upon the quality of the earth used. At certain places it is an extraordinary thing, that though such roofs crack badly during hot weather, when it rains, the cracks are automatically filled up by the loose earth carried by the rain-water passing over them, and the roofs are rendered perfectly watertight in spite of heavy rain.

Such roofs, however, need careful attention both in the beginning and at the time of subsequent repairs, and where good earth is not available, they are sources of considerable

trouble and inconvenience, and sometimes of danger, if the walls are of earth, or even of brick or stone in mud mortar. Again, in places where trouble from white ants is feared, the timbers have to be renewed at short intervals.

If C. I. sheets are used instead of the reed or wattle and the roof made as usual with a layer of good quality of earth, not only an absolute protection from rain is obtained, but the covering of the earth removes every fear in respect of both, the roof being blown away by wind, and heated by the sun. Of course, the necessary slope must be given to the surface. An additional advantage in respect of cheapness given by this sort of roof, is that as the incline is small, fewer sheets are required than for the usual sloping C. I. sheet roof and that the stiffness caused by the corrugations saves a considerable amount in timber supporting them, as the spacing apart of the latter can be safely increased. If mild steel rolled sections are used for purlins, the roof becomes ant-proof and practically a permanent structure.

Before laying the sheets in position they should be given two coats of cement with a brush; this would prolong their life. In order to make mud roofs watertight, the remedy suggested for making exposed surfaces of mud-walls watertight on page 99 may be tried with success.

## CONCRETE TERRACES.

Concrete terraces, whether of lime concrete, or cement concrete, must have a rigid sub-layer. Even a slight movement in it, whether due to mechanical agency or to expansion and contraction caused by heat or cold, causes the concrete above it to crack and through the cracks water leaks. Wood is therefore, quite unsuitable, as it swells by moisture and as a result expands and contracts considerably. Iron and steel in the form of rolled sections are much more preferable, as they do not swell and behave as much more rigid material than wood.

The upper concrete layer in terraces is carried on either jack arches, or on tiles or stone slabs etc. The tiles or slates are laid on steel joists or wooden beams. The concrete is made of 2½ parts of the broken brick bats, one part of unscreened sand, and one of lime mortar. The pieces of brick-bats are allowed to soak in water freely for 2 or 3 hours before mixing. The concrete should be laid in a stiff state and beaten well. During the process of beating, the surface should be sprinkled with water, in 8 *gharas* or 6 kerosene oil tinfuls of which, is dissolved 3 seers of molasses and 2 seers of *beal* fruit. The success in respect of compactness, which is synonymous with watertightness, depends upon the thorough consolidation made.

This should be done by beating for three days, and should only be stopped when the rammer rebounds and a heeled boot cannot make a mark on it. Clean water should then be freely sprinkled and when the cream of lime at the surface is softened, the surface should be rendered smooth by polishing with a trowel. No fresh mortar or cement should be added, as it forms a skin layer which soon swells and forms hair cracks.

In order to render a terrace roof quite watertight, the surface of the concrete should be coated with hot bitumen, and over it, should be laid, flag stones or tiles, filling the joints with cement mortar.

Another method of making a watertight tarraced roof is to lay, on top of lime concrete, flag stones of as large a size as practicable, so as to minimise the number of joints, which form the only weak spots. When paving stones are laid, the joints of the slabs should be kept 1 inch to 1¼ inch wide and they should be raked out to their full depth and filled in again with cement mortar consisting of one part of cement and two of fine sand. The idea is, that if leaks occur at all, they will do, through the joints only, which, in the first place are much less in number, and again, have received a special treatment with cement mortar. Hence, the chances of leaks occurring are few.

However, if they occur at all through some of the joints in course of time, through hair cracks formed in them, it is a simple matter to open them by a chisel and fill in asphalt or some other waterproofing material and end the trouble once for all, at a small extra cost. The purpose of keeping wide joints, is that they should admit of a chisel being used for opening them.

# DOMESTIC SANITATION.

The fundamental principles underlying perfect domestic sanitation are inunciated below :—

(1) All refuse and waste matter, whether solid, liquid or gaseous, which is offensive and injurious to health, must be removed away from the house, as rapidly after it is produced, as possible, and disposed of in such a way as to render it harmless.

(2) That no part of the house should hold damp anywhere.

(3) That all substances which are of such a nature as to absorb, catch, carry, hide, or retain particles which are likely to hold germs of diseases, must be avoided as far as possible, whether employed in the structure of the building itself, or in decoration and furnishing ; thus porous and absorbing bricks, sea sand impregnated with salt, which absorb moisture, are bad. Thatch, for roofing which is sure to decompose, is bad ; stone carvings, embossed plasterings, mouldings, ornamental railings, cotton or woollen fluffy carpets etc. which are likely to catch, hold, or hide dust, are bad.

(4) That every room of the house must be provided with adequate means for admission

of fresh air and expulsion of used air, so that it is continually charged with a stream of fresh air.

(5) That every part inside the house including every nook and corner should be fully lighted as far as possible, by the direct light of the sun.

(6) That the house should be supplied with a copious supply of pure water.

Let us take these in order and see how they can be enforced to suit the peculiar conditions of India, caused by the habits, customs and religious prejudices of the people.

All refuse matter may be divided for the sake of convenience into two classes :—

(1) Matter of fæcal or excremental nature both human and animal.

(2) Other waste refuse, such as straw, ashes, waste papers, rags, garbage etc.

The first is of the greatest importance, because if it is not efficiently removed from our surroundings, it soon decomposes and the germs of diseases, such as Infantile Diarrihœ, Dysentery, Cholera, Typhoid etc. are disseminated by flies and dust reaching the eyes, food, milk, and water.

The only satisfactory means of efficient removal, especially of fæcal matter, is the

water carriage system with underground drainage. It also simplifies its disposal. But India is so backward and poor, that whereas the system prevails in all towns and most of the villages in the Western countries, not more than two dozen cities and large towns in the vast continent of India, can boast of it. In villages and small towns there are often no Municipalities at all. There are, therefore, no sweepers and scavengers to remove the filth from premises of houses, which are used by young children and often by women, for answering the call of nature! Males do so in and around the village site, wherever some privacy is afforded by shrubs, mounds or banks of earth, stone quarries etc. The fæcal matter is allowed to decompose and dry, during which period it attracts swarms of flies. It is then constantly stirred up under feet of cattle and men and when reduced to powder, is blown away by wind to be deposited on water and foodstuffs and to be inhaled into lungs.

Even the cities and towns blessed with Municipal organisations, are not a whit better. In the first place more than 50 p. c. of the houses have no latrines of their own, with the result, that the same conditions as those described above prevail perhaps in a worse degree, because the houses being crowded, and there being no open space available round them,

the streets are made use of, anytime by day by children, whom their age gives a privilege in respect of privacy, and by grown-up people, during the small hours of the morning or after dusk. The free public latrines provided by Municipalities are either inadequate in number or the people are so sloventy in their habits that most of them do not take the troubles of walking a few steps to take advantage of them. Even where latrines are built, the open drains of the street receive the contents of the overflowing baskets in the latrines; the semi-fluid matter stagnates in the gutters and forms a breeding and feeding ground for the flies and mosquitoes. The habits of some people are so bad that even the most enthusiastic and conscientious sanitary inspector even though backed up by the authority of law, soon becomes disheartened in his thankless task and loses much of his efficiency.

Poverty and ignorance of the most fundamental principles of hygiene, coupled with conservative and religious prejudices, are some of the causes. The only remedy is education by proper methods, such as, popular lectures with the aid of lantern slides, health exhibitions, broadcasting leaflets, posters etc. by *volunteer* organisation rather than by authority. If a band of enthusiastic volunteers in each village or town go on rounds and by actual example

rather than by precept show how to clean the town or village, wonders would be worked out in a short space of time. The author has actually organised such a volunteer corps and he writes from personal experience. Enthusiasm is never wanting in youths and if under proper guidance they are taught to clean up with their own hands the stink left by insanitary householders and if they have once absorbed the spirit of social service and do it whole-heartedly, not only would those responsible for the filth be put to shame and taught a lesson, but the gospel of the dignity of labour and social service would be brought home to them in a more telling manner against the age long habits and religious prejudices, than any amount of effort made in all other directions.

Really speaking in villages and small towns where there is generally some elbow room, at least in the rear yard of the house, the problem of dealing with the sewage produced in the individual homestead, should present no difficulty. But unfortunately a strong determination and an earnest desire to solve the problem is lacking on the part of the people.

It is not possible to give in the short compass of this book the various types of latrines and to describe the various methods of dispos-

ing of sewage ; this has been attempted at some length in the author's other book. It is proposed to describe here only two very simple and cheap methods, one, suitable for town areas where there are municipal scavengers, and the other, suitable for rural areas, where some method of rendering the sewage harmless then and there has also to be adopted.

From the foregoing discussion it will be seen that the conditions which an ideal latrine must satisfy are :—

(1) That it should not give out noxious smell.

(2) That it should not attract flies and other vermin.

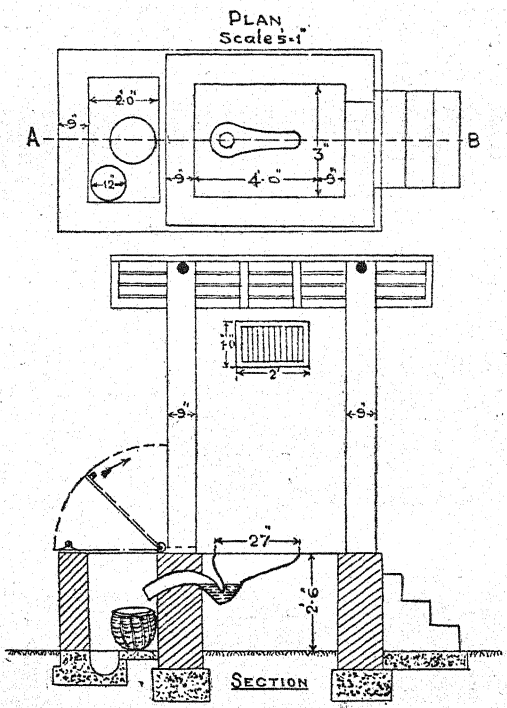
(3) That the contents should not be visible to the user.

(4) That the night soil and the liquid contents should either be removed away from the site at the earliest opportunity or suitably treated so as to render them innocuous.

Let us see how the two types to be described below satisfy these requirements. To take the one, which is suitable for municipal areas first :—

Figures 46 & 47 show a simple design of a latrine which does not differ much from the

ordinary ones usually constructed in municipal




Figs. 46 & 47.

areas where the night soil is collected in baskets and removed to a distant place by sweepers.

In fact, any type of latrine can be improved by making additions and alterations in it. The outstanding features are an earthenware closet of a simple design laid just below the seat to receive the liquid and the solid excrements. Such sorts of closets are manu-

factured by Burn and Co. and sold for Rs. 8. Its plan, and a section are shown in the sketch. It is glazed on the inside and has got a sloping bed, so that the contents slide down to the lowest level where a trap is fixed which always holds a certain quantity of water. The human excreta, as soon as they fall down drop into this water. The ablution water causes them to be pushed through the pipe into the basket placed below.

Thus they being always covered by water, no noxious smells are given out. There is no connection between the seat side and the basket side of the latrine except through this pipe, the neck of which being always sealed with water there is no possibility of any foul gases from the basket side coming to the seat side unless the trap runs dry. As the basket is hidden from view, its contents cannot be seen by the user.

There is a small rear chamber of burnt brick in lime with inside dimensions of 2 ft. by 3 ft. Its bottom and sides are lined on the inside with cement plaster and there is, in one of its corners, a small pit also lined on all sides for holding the liquid contents. The bed of the chamber is made to slope towards this pit. The chamber has a cover of galvanized iron sheet at top which is hinged to the hooked bolts, inserted in the rear wall of the latrine. As the contents

of the closet above, fall into the basket which has got numerous holes in the bottom and sides, the solids are deposited in it and the liquid which is separated by these holes flows into the pit. The sweeper has to lift the lid, remove the basket with its contents, scavenge the floor, remove also the liquid contents of the pit, put the empty basket in position and replace the cover before he goes away. The efficiency of this arrangement is due to the fact that as the chamber is always covered, there is no chance of flies sitting on the filth. The whole thing remains quite clean and hidden from view. An occasional coat of coal-tar or better still of pesterine to the cover and the outside of the chamber is recommended.

If the earthenware closet with trap is omitted by those who cannot afford it and instead of it a simple half round 6 in. diameter earthenware pipe is fixed in a slanting position on the top of a trap it would serve the purpose. But the closed chamber on the rear side is absolutely necessary if flies, which transfer germs of disease are to be excluded.

2. For rural districts in non-municipal areas :—

As there are no sweepers here, two distinct functions have to be done. One, of collection of the fæcal matter and the other, of rendering

it harmless. The first is done in a latrine, the essentials of which, in rural area, are that (1) it must be very simple, so that, even an unskilled village artisan can both make and repair it; (2) it must be cheap and (3) it must be light and portable.

Figs. 48 to 50 show a suggestion of a design

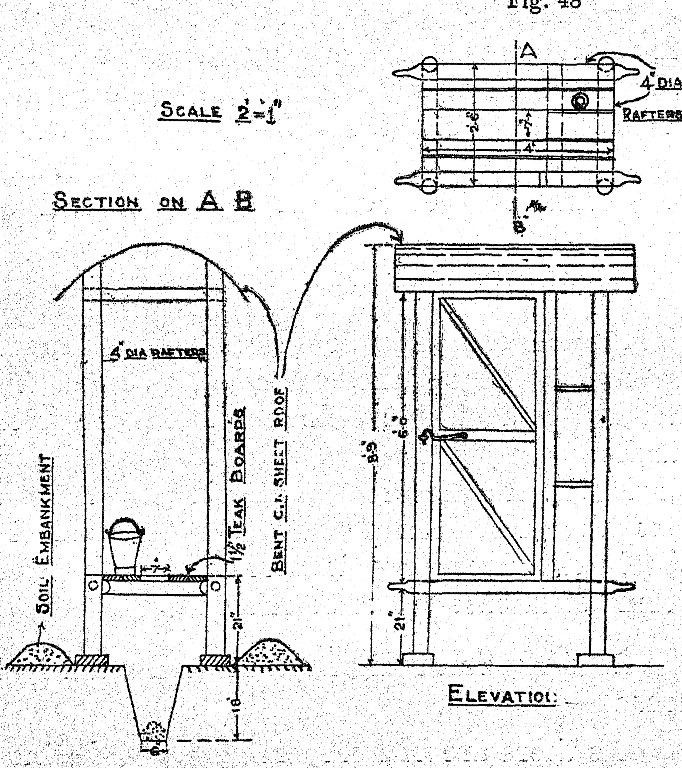



Fig 49

Fig. 50

for one, which the writer has experimented

upon and found to give entire satisfaction. It can be modified as desired to suit the local circumstances. The squatting platform (Fig. 48) consists of a frame, made like an ambulance stretcher with projecting handles, of two longitudinal and three cross pieces, either of round teak rafter 4 inch diam., or roughly squared country timber. Upon this are nailed 1½ in. boards, so as to leave a lengthwise central gap 7 in. wide and 2 ft. long, to form a seat. 4 ft. by 2¾ ft. is a convenient size for the platform. The latter should then be fixed to four vertical posts at corners, of round rafters 3 to 4 in. diam. and 8 ft. long, at 2 ft. above the ground surface. The walls may be of double bamboo matting nailed to posts by means of split bamboos, with a door of the same material. They may be coal tarred on the outside and white washed on the inside. The roof may be of c. i. sheet bent to an arched shape screwed to iron flats similarly bent and bolted to the ends of the posts. The door should open outside and be preferably self-closing.

This portable latrine should be centrally placed above a trench 6 inches wide at bottom, 18 in. to 24 in. deep, with sides sloping according to the nature of the soil and subsoil. The earth excavated from the trench should be deposited in long ridges on both sides to exclude rain water.

A bucket full of ashes and dry earth mixed in equal proportions with an iron scoop in it, should be kept inside the latrine. Even dry earth without ashes would do, though ashes are better. Each time the latrine is used, a small quantity should be spread with the scoop so as to cover the excreta. A separate stock of dry earth should be maintained for use in the wet season, just like that of coal or fire wood.

When a portion of the trench has been filled up, say to 6 in. below ground, the portable latrine should be moved forward a few inches and the portion previously used filled to the ground surface with earth drawn from the inner side of the ridges.

A trench 10 ft. long would last for over 8 or 9 months for a family of 6 souls.

If good dry earth is used in sufficient quantity and some arrangement is made to cover the sides of the latrine below the squatting platform, the contents of the trench will be in darkness and no trouble from flies will arise. However, if additional safety is desired, pesterine or even crude oil may be sprayed once a week over the trench and even on the platform, by means of a Flit pump sold for a rupee. Crude oil is sold at so cheap a rate of 5 annas per gallon. One gallon would be sufficient for a year.

Such a complete latrine would cost Rs. 14-12. Those who can afford to spend more, can provide four wheels with axles instead of posts resting on ground, fix galvanived iron sheet on the top of the platform and also for the walls and door. Fig. 51 shows a photograph of one such working latrine.

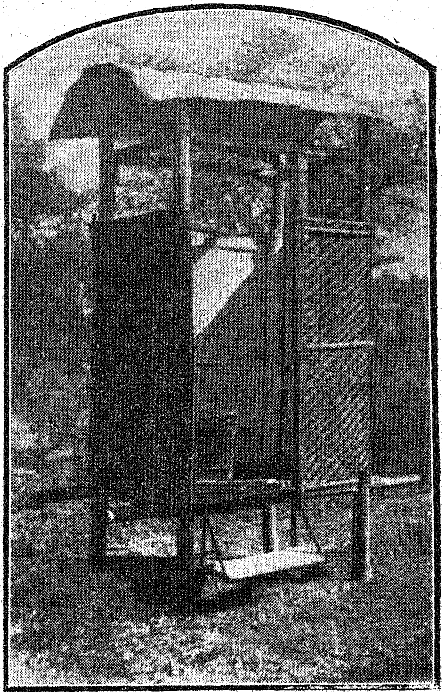


Fig. 51

Advantages of this system are :—

(1) If the necessary precautions are taken, the system is most sanitary. It works

so satisfactorily that even the user of the seat cannot feel any stink.

(2) It affords the best privacy and is always ready at hand especially for the sick and decrepit. Where *purdah* system is observed, the ladies, whose lot is otherwise miserable in the absence of any latrine, will appreciate it most. It is to be noted that one of the reasons why decent folk avoid the country-side is that they do not get privacy in this respect.

(3) It is very cheap. It can be prepared by a village carpenter and a cheap model as above, would cost only Rs. 14–12 including cost of labour and material.

(4) The materials required for its upkeep in a sanitary condition viz. ashes and dry earth are obtainable anywhere. Coal tar and crude oil also are very cheap.

(5) It is superior to earth closets, because firstly, the earth closet is of a limited capacity. Indians cannot do without water for ablution, and the water used makes the fæcal matter wet and sets decomposition. To prevent this, lot of earth must be used, but if this is done, the ordinary earth closet gets soon filled up. In the portable latrine described above, not only the sides, but also the bed of the trench are all absorbent and of deoderising material and the latrine is of unlimited capacity; hence, all the

water used for ablution is readily absorbed by it.

Secondly, the earth closet is comparatively very costly. It has to be built in masonry with cement lining on bottom and sides; a ventilator is also required. Thirdly, emptying of the earth closet is a very irksome task especially to the Indian sentiment. It has to wait to be done only by persons of a particular class. The Indian householder has no appreciation of its manurial value. He would fain build another or rather do without one, than undergo the trouble of emptying it. In the system mentioned above, its manurial value is automatically realised without having an occasion to empty the trench. Because, whatever is grown over or near the trench gets full benefit of the manure.

(6) The fæcal matter is converted into harmless humus by the bacterial action within 8 days, after which, it becomes just like ordinary earth. In this respect, the shallower the trench, the better. But a shallow trench is only possible when the extent of ground available is large, otherwise, it would soon get filled up.

(7) As the latrine is moved from place to place, there is no likelihood of any great concentration of sewage occurring at any one place

as is likely to happen in a cracked earth closet or a cess-pool.

## PRECAUTIONS TO BE TAKEN

For efficient working and perfect safety, the following additional precautions should be taken :—

(1) If a choice of site is available, the trench should be located in a place, from which wind will not blow towards the house. This is just to preclude any possibility of foul gases being borne by wind towards the house, should the system go wrong at all.

(2) The site should be as far away as possible from a well, if any, of drinking water. When this is not possible, the trench should not exceed one foot in depth, and earth should be more freely used. So that the sewage, instead of concentrating on a limited area will get a chance of being better purified in a shorter time on a larger area and thus the chances of well water being contaminated by its sokage into the ground, would be minimised.

(3) The trench should be at such a place that rain water will not flow towards, and accumulate in it. If necessary, a cut-off trench with a small protective bank may be provided as additional means of safety.

## DISPOSAL OF URINE.

We now come to the question of the disposal of human urine. The usual practice of committing nuisance indiscriminately in the premises of the house is to be strongly condemned. It is forbidden by sanitary law even to abuse a street corner in this way, and one who misuses such places is liable to be prosecuted before a magistrate. Some people make use of sinks in the bath-room for the purpose. Though this is better from the point of view of privacy, it is also objectionable unless there is a flushing system with under-ground drains, or copious water is used by hand on every occasion for flushing, and further, the water is treated suitably. The best way is to build a small urinal in a corner of the compound outside the house with earthenware half round channel at least 6 ft. long to carry the urine exposed to sun, and to provide a supply of water for flushing purposes. The floor should be either of cement concrete or of stone; if of the latter, it should not contain lime in its composition and should be dressed smooth. If the diluted urine passes through the open channel and is absorbed by ground exposed to sun, it is rendered harmless.

Another way is to keep a China or enamelled pot with a large mouth and a close cover with some saw-dust in it. Each time use is made, some ashes should be sprinkled on the

saw-dust. At the end of the day the pot should be emptied in the manure pit, washed and kept for use again. Saw-dust holds its own volume of urine and prevents any possibility of its being spilt, and ashes check putrefaction and have also a deodorising effect.

## DISPOSAL OF HORSE AND COW DUNG.

Then comes the question of the disposal of other excremental matter viz. that of domestic animals such as cows, horses etc. The question of collection and disposal of it in rural districts and in dairies, stables of horses kept for public use, etc. where the dung of a large number of animals has to be dealt with, requires special consideration, which is outside the scope of this book. It is only of an animal or two which are usually kept by middle class men, that is proposed to be discussed here.

The usual practice is, in municipal areas, to throw the waste fodder and litter into the municipal dust-bin and utilise the cowdung for preparing dung cakes to be burnt as fuel. In small towns and villages, where there are no municipalities, the former is thrown into a muck heap close to the house and the latter used for the same purpose viz. preparing cow-dung cakes for fuel. The latter is a very bad

practice both from the economical and sanitary point of view; because, its value as a manure is several times greater than that as a fuel. Again, considerable time is wasted on the preparation and drying of cowdung cakes, which can be best utilised for more important work. When the agriculture has been starving for want of manure and has been yielding very poor or no crop, it is a pity that we should burn cowdung which is an excellent manure. Every one—no matter whether he is an agriculturist or not—must regard the burning of of cowdung cakes for fuel as a National waste and a sin against agriculture.

The best way of treating dung of domestic animals is to store it in a pit in the compound as far away from the house as possible, situated in such a place that the wind will not blow from it towards the house. The ideal conditions are, that instead of an underground pit a masonry chamber lined with cement on the inside should be constructed above the ground with a roof over it. The door for throwing the dung into the chamber should be self closing. There should be another door for removing the manure and a ventilating pipe carried high above the ridge for letting out foul gases; but the middle class people of India cannot afford this. Hence, we must be content with a pit excavated in a distant corner.

The danger in this arrangement consists of contamination of the water supply of wells if situated at hand by the sewage percolating through such pits. When such a manure pit is started, the unpolluted soil surrounding it is able to filter the liquid portion, which thus reaches the water-bearing stratum in a fairly pure condition, but as the strata forming the filtering media become polluted by soakage of the sewage, they lose their power of filtration and the liquid sewage passes unfiltered to a lower and lower level until it ultimately reaches the water-bearing stratum from which the wells derive their water supply.

To guard against this danger, the following precautions must be taken:—

(1) No liquids should be thrown into the pit. Every possible precaution should be taken to divert rain-water flowing towards the pit. In other words, the contents of the pit must be kept as dry as possible.

(2) The pits should not be very deep; but this is possible only if the space is ample.

(3) The pits should be lined on the sides and bottom with brick or stone masonry and plastered with cement if the substrata are very pervious.

(4) Ashes, dry earth, and similar deodorising agents should be occasionally spread in sufficient quantities in the pit.

(5) The pit should be emptied at short intervals and the manure utilised for agricultural purposes.

(6) Some sort of roof though not absolutely water-proof—say even of thatch—should be erected to prevent rain from falling into the pit.

To keep off flies feeding and breeding on the heap in the pit, it should be covered with waste fodder from the shed or stable on which should be sprinkled crude oil from time to time.

## DISPOSAL OF SLOP WATER.

The next thing to be considered is the disposal of the waste water which goes under the general name of sullage water as distinguished from sewage. It consists of slop water from the kitchen, sink and waste water from the bath-room. The present practice, in municipal areas where there is no water-carriage system, to allow it into the open street gutters, is very pernicious. The channel leading thereto, from the sinks is often not well graded, nor constructed of water-proof material, in consequence of which, the water generally soaks into the ground close to the house, causing damp to rise and mosquitoes to breed. Even if it finds its way to street gutter, the

latter are generally choked with debris, which obstructs it and the same result follows if only a little further away from the house.

In non-municipal areas no attempt is made to lead the water away from the house at all and in consequence it soaks into the foundation of the wall and the floors of the house causing damp and stink to rise and mosquitoes to breed.

The proper way of disposing of the sullage water is given below.

At the outset it must be remembered that water from latrines which contains pure sewage of a dangerous character, must in no event, be allowed to enter the drain meant for sullage water. The sewage requires quite a different treatment which has already been described in a previous chapter. The slop water from kitchen sinks and the waste water from the bath rooms, the composition of which is different, require slightly different treatments in the earlier course; because the slop water from the kitchen contains some oils and fats, cream rising at top in the congee (gruel) while boiling the rice, peels of onious and vegetables etc., which must be first separated. Otherwise they are not only liable to choke the drains, but the fats in them render the problem of disposal of the water difficult. The waste water from

Indian bath-rooms is in most cases likely to contain urine. Hence it is safe to take some precautions to prevent foul gases from entering the house.

A sink in the kitchen need not be larger than 2 ft. by 2 ft. If it is to be used only as a kitchen sink, i. e. not for occasional bathing, even 18 in. by 18 in. will suffice. The flooring should be of a flag stone in one piece with a slope towards a corner and not towards any side. A piece of pipe at least 2 in. in diameter should be laid for leading the water to the outside. The pipe should drop the water on to the top of grass put into an iron bucket or half cut kerosene oil tin with perforations at the bottom. Thus all the solids including fats, will be arrested by the grass allowing only the slop water to trickle down. There should be another small chamber, lined with cement on the inside, just 6 in. deep below the perforated tin for collecting water and allowing it to run through a drain of half-round 4 inch earthernware pipes starting from it. The drain should be open throughout and as long as the space will permit. The water should finally be led to the roots of vegetable or flower plants by turn.

In the absence of any flower or vegetable garden, the water should be collected in a cement lined masonry cistern, from which it

should be daily taken out by hand-bucket and sprinkled over open ground for being purified by the action of the soil and the sun's rays.

If the surface of the ground be limited in extent, some sort of vegetation—even grass may be grown on it. Roots of living vegetation very quickly absorb and assimilate the impurities and render them harmless. The same treatment is required for waste water from bath rooms except that a *Nhani* trap illustrated in the Figures 52 and 53, should be fixed in a corner of the sink towards which the floor should slope. This trap has a water seal which prevents foul gases from the drain rushing back into the bath room.

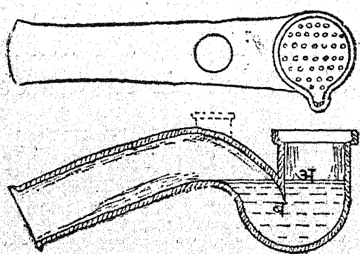


Fig. 52 & 53

The object of the long open drain for carrying slop water is, that by exposure to the air, sun-heat, cold and drying winds, the putrefaction is checked and the production of foul gases is rendered impossible.

Subsoil irrigation and pit filtration are other remedies for the purification of the slop water, but are not recommended in consideration of the habits of the Indian people. For, unless carried out on strict sanitary principles,

they are very likely to prove a greater evil by becoming the breeding grounds of mosquito-larvæ.

## DISPOSAL OF DRY REFUSE.

We next come to the question of removal and disposal of dry refuse such as sweepings from the house, rags, pieces of paper, peels of fruit, leavings of food, plantain or other leaves used as dishes etc. etc.

For perfect success in this respect a radical change in our habits must be effected. Even the young children must be trained not to throw carelessly about pieces of paper, peels and stones of fruits, shells of ground-nuts, chewings of sugarcane etc. not only inside the house but also outside. They should be trained systematically to put them into small receptacles provided with lids and placed in a corner of every important room. Even grown-up people are in the habit of throwing, through windows or door openings that sort of litter into the compound and the idea scarcely enters their minds that they are doing even a greater harm than by throwing it inside the house. For, if the litter be scattered inside, the rooms of the house get a chance of being swept once or twice a day, but if such waste things are thrown into the compound they decompose, vitiate the air surrounding the house with foul

gases, which are inhaled by the inmates. Such rubbish attracts flies, which transfer disease germs from its surface to the articles of food. For this purpose, the premises of the house must be kept as scrupulously clean as the inner apartments. It would be a great advance upon the existing state of things if the plan were universally adopted, and every one in the household would do his, or her bit, not in cleaning, but in preventing, dirt by acquiring cleanly habits.

The receptacles in which dry refuse is collected, should be emptied at least once a day in dustbins in municipal areas, and where municipalities are not existing, they should be treated as described later on.

The public dustbin in India is an abominable nuisance. It is never used properly, for fear of the user being defiled, if one happens to touch it. The contents of the receptacles are thrown in from a distance, with the result that hardly half the *kutchera* falls into it while the remaining half falls outside it. The next person, especially if she be a female, is afraid of touching the rubbish scattered outside by the previous person for the same religious prejudices as above, and empties her basket from a still longer distance. Ultimately half the street is reached by the heap of the refuse meant for the dustbin leaving the latter

practically empty. Such a scene affords a suitable place for the young chirldren of the adjoining houses to commit nuisance. If a dinner or a feast was given in any of the houses in the street, on account of the celebration of a marriage or of like festive occasions, the plantain or other leaves used as plates for the dinner are thrown near the dustbin with remnants of food sticking to them. Stray dogs, crows, pigs, cats, and hens stir up and scatter the rubbish with a view to feed on it; wind further helps and thus the entire street often presents an appearance of a muck-heap until the weary and indifferent municipal sweeper comes with a bullock cart to collect and remove it hap-hazardly with no special mission, to confer the boon of sanitation upon the locality.

In moffussil areas where there are no municipal organisations, it is advisable to sort out the rubbish coming from the homesteads. The portion which is capable of rotting, should be put into the manure pit and covered with ashes or dry earth, and that which is capable of drying easily, should be burnt in a pit and the ashes so obtained used for covering the manure pits or trench latrines. Those who can afford to spend more should build simple types of incinerators which burn such rubbish efficiently in a short time without producing volumes of smoke.

## PREVENTION OF DAMP.

We next proceed to the 2nd principle of domestic sanitation viz. that the house should not hold damp anywhere. Enough has already been said about the prevention of damp while building a new house. We shall now confine our remarks to the question of how to remedy the existing one. For this, the root cause of the damp must be first found out and remedied. Very often it will be found to be due to defective drainage. If it be due to the choking up of a drain somewhere, the obstruction should be detected and removed. If it be due to very insufficient slope given to the drain, the latter will have to be regraded. It may perhaps be due to a leaky joint which should be traced out and mended.

If the damp be due to a leaky roof, the water of which soakes into the wall, the leak should be located and set right, Sometimes it is very difficult to find out the exact spot of the leak in a pitched roof if there is a ceiling below it; because the water drops on the ceiling and finds its way somewhere else through it. If it be a flat terraced roof with concrete at top, a search should be made for cracks and they should be filled with a water-proofing compound. Sometimes there is no crack distinctly visible, but there are innumerable hair cracks spread over the surface

through which water percolates. This can be remedied by giving one or two coats of a water-proofing paint such as hot bitumen.

The damp may perhaps be due to rain-water collecting near the house in a depression. This should be drained off and arrangements should be made so that rain-water runs fast away from the house before it gets time for accumulation and soaking in. The cause of the damp often times lies in the mud or earth used for the flooring of rooms, containing salts which absorb moisture from the surrounding soil or even from the air. To remedy this, at least one foot layer of the earth at the surface should be removed and replaced by other good earth which does not contain any moisture-absorbing salt, and the floor remade. Or the old earth should be washed to leach out salts from it (vide page 29).

Often the site is sharply sloping causing the plinth of the part of the house to be at lower level than the ground surface on the other side so that damp necessarily rises in the floors and walls in that part. This can be remedied in either of the two following ways:—If the difference in level is considerable and also damp serious, excavate a trench close to the outer wall on the side of the high ground, down to the foundations, wash the face of the stone

masonry, rake out joints and point them with cement mortar, and in addition to this, fill the trench with moist earth, of the nature of black cotton soil (*regur*). If the earth has to be brought from a long distance, cover only 6 in. width of the trench touching the wall with it and remaining width with the earth excavated from the trench, side by side, in 6 inches layers as shown in figure no. 54 and ram well up to the ground surface. The black earth is

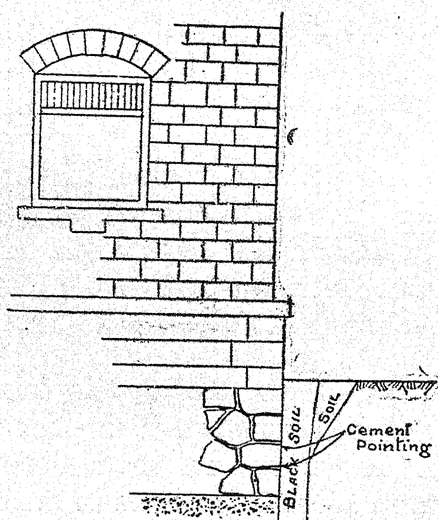



Fig. 54

impervious to water and effectually blocks the passage of water towards the house. If the wall be built in burnt brick, the portion below ground in which damp has appeared must be

plastered with cement before filling the trench with black soil.

Another remedy is to excavate the floors of rooms to a depth of about 15 in., remove the stuff and fill in pebbles and gravel from riverbed of sizes, varying from 4 in. to 1 inch to a depth of 9 in. and remake the floor on top of this; this would make it free from damp. If a layer of about 4 in. of concrete is laid at top, it ensures perfect protection from damp.

Sometimes there is a large source of water-supply at a higher level and the ground below it is permeable, through which water percolates and rises in the form of damp. Very often a whole village is affected in this way. The only remedy is to excavate a trench on the upper side of the house or village, deep enough to cut through the water bearing stratum such as murum, sand etc. A suitable bed-fall should be given to the trench and it should be made to join a nalla or a river. The trench should be filled with boulders of stone and the top portion made good by filling earth. The trench will cut off and carry to the river, the water which would otherwise have caused damp.

## PREVENTION OF DUST & DIRT.

We now come to the third principle of domestic sanitation viz. avoidance of dust. To

what extent the atmosphere is charged with dust needs no demonstration. One can actually see the particles lit up by a beam of the sun entering a dark room in a house. How the cloud of dust rising behind an automobile running on roads suffocates, for a few seconds, the passing pedestrians, is a matter of every day experience. Part of this dust cloud unfailingly finds its way in dry weather through every chink, and door and window opening in the house walls and settles in a thick layer on the horizontal surface of every article in the house. It mingles with the food we eat and with the liquids we drink. One would be startled to find what a large quantity of dust one must be sucking into the lungs during the process of breathing, when it is considered that an average man inhales 16.6 cub. ft. ( or 33 average sized pitcherfuls ) of air per hour.

The street dust has become so familiar to us that we have lost the sense of appreciating the incalculable evil in it. Street dust when examined under a microscope is seen to be composed of powdered mud, particles of human excreta, powdered droppings of horses and bullocks, particles of decaying bodies of dead animals, such as cats, dogs, rats, etc., particles of soot, fibres of cotton, hair, etc. etc.; all contributing their quota in forming the savoury compound called dust.

Every particle carries with it hundreds of microbes of disease. Fortunately we are provided with a delicate apparatus which prevents even a single particle from finding access to the lungs proper. Otherwise untold calamity would have been the result. The particles are driven back to the throat from where they are swallowed in the stomach. Still, they affect the throat and cause irritation; bronchitis is said to have its origin very often in dust. Sore eyes especially of children is another result.

Again, the dust produced by certain trades is poisonous. Thus the dust produced while manufacturing lead and arsenic paints, grinding metals etc., is full of poison. The dust in the ginning factories is full of microscopic particles of fibres of cotton which are found to clog the passage of lungs.

If it is realised that dust and dirt mean disease, all that lies in our power must be done to minimise the harm due to the evil. There must be no recesses or ledges, no cornices of complicated designs, no *jalis*, carvings and other ornamental work, no furniture except that with plane surfaces, no fluffy carpets of wool nor cotton that hold dust and yield a cloud of dust when shaken etc; Even nitches and open shelves in which things are likely to be stowed away and left undisturbed for months together, are objectionable. It is desirable

even to go to the extent of making the bottoms of windows on the inside, sloping instead of flat, to preclude the possibility of any articles being put there. For, not only do they obstruct ventilation but are in addition, sure to catch dust. There should be an ample provision of cupboards in walls and all of them should be closed by close-fitting shutters, no matter of whatever cheap material.

Some people are very fond of crowding the rooms with unnecessary furniture or lumber. They make the task of the housewife or servants very difficult and if the latter are slack in carefully dusting them every day, which they are, sure to be, in nine cases out of ten, the articles are bound to accumulate dust and dirt.

In short, strictest attention should be paid while designing and building a house that the labour of keeping it clean would be the minimum.

## VENTILATION.

Air is a prime necessity of life which becomes extinct if the air supply is cut off even for a few minutes. In a closed room the effect of animal respiration is doubly adverse on the air enclosed. For, when we inhale, we consume oxygen from it, and when we exhale

again, we render it impure by filling it with carbonic acid gas and water vapour. Impure air causes head-ache and sickness and ultimately devitalizes the person; because with the deficient supply of oxygen the process of purification of blood is checked. The man looks pale, loses vigour, activity and the power of resistance to the germs of disease and thus falls an easy prey to it.

This is what exactly happens in India. The reason, why Malaria, Cholera, Plague, Small Pox etc, take such a heavy toll of human life in India, will be found in the most devitalizing conditions caused by deficiency of adequate light and ventilation and prevalence of general insanitary conditions in the dingy and stuffy rooms in the houses, especially of the lower classes. The high death rate particularly amongst infants and women, has its origin in the over-crowding of rooms and deficiency of fresh air and light in ill-built, congested houses. Men go out into the open air at least for some part of the day but the females of the middle classes and especially those in *purdah*, have to confine themselves for 24 hours in the house. The young and innocent infants whose strength and power of resistance are naturally very low, are further devitalized by want of sufficient oxygen, and consequently succumb to diseases, even with a slight change in the atmospheric conditions.

In many towns the depth of houses, front to back, is excessive and the houses in most cases touch each other with the side walls in common between two. In rare cases where a small passage or gully exists, it is generally not more than 2 ft. in width which is quite inadequate to supply fresh air and light to rooms; on the contrary, it is so full of filth and decomposing matter thrown from windows on either side that to exclude the foul gases, the windows have to be normally closed. As a result of this the buildings are deficient in ventilation and light, the central rooms being often in absolute darkness requiring a candle to light them when required even by day. They are dependent for ventilation upon the passages within the house.

In villages and small towns one or two small square holes scarcely exceeding one or two square feet in area are provided, in the walls even though the entire wall surface may be exposed to light. These holes are also closed by night for fear of draught and burglers, some times by permanently fixing gunny cloth, by nails against the closed shutters, and in the small space enclosed within the walls, all the members of the family sleep on the ground by night. It is a common practice to allow in the same room calves, goats, poultry, the latter covered under a loaded wicker basket. Were it not for the

chinks in the ill-fitting doors and the crevices in the crude form of the tiled roof, through which some air enters, they would certainly die of sheer suffocation. Never-the-less, the bad effects must be there especially on the health of infants.

The remedy consists in educating the public mind in domestic sanitation and personal hygiene by every means possible. Aid of legislation, if possible, may be taken in the beginning.

With this slight digression for which no apology is required, let us turn to the subject in hand. Ventilation connotes much more than mere providing of fresh air. The old theory that carbon-di-oxide ($CO_2$) is a poisonous gas and if its proportion in the air exceeds a certain limit it proves fatal, has been exploded. It has been recently proved by experience and experiments that it is not a poisonous gas, and that breathing of air containing percentages of $CO_2$ which at one time would have been thought dangerous, has practically no injurious effects. On the other hand, it is now held in scientific circles that the more important factors, in rendering the air impure are, the organic matter continually given out with exhalation of breath and the humid emanations proceeding from the skin surface. One can verify these facts if one only brings

to one's mind how foul the matter deposited on teeth is, which is nothing more than a part of what comes with human exhalations, and how offensive the stink of clothes, worn for a long time, is. Thus not only the respiratory organs, but the whole body is continually breathing. There are also other factors viz. the heat produced by warm breath and the water vapour contained in the exhalation, which increase the temperature and humidity respectively of the air in a closed room; because, upon them wholly depends the sensation of stuffiness or otherwise which one usually experiences, in a crowded place. When we enter, for instance, an occupied railway compartment with windows closed during night, the warmth experienced is due to the rise in temperature of the air, the bad odour is due to the organic matter in the form of microscopically small particles emanating from breath and skin surface of the occupants, the perspiration caused, is due to the excess of water vapour present in the air, and the general uneasiness experienced is due to the deficiency of oxygen and all other above mentioned causes combined together.

Despite the fact that the purpose of ventilation is the promotion of a healthy and comfortable atmosphere in our rooms, the latter is often deceptive. The ventilation of a room may produce an agreeable and pleasant sensa-

tion to an occupant and still the condition of the air in it may be far from the standard sanitary requirements. The sensation of the pleasantness or oppressiveness depends upon the relative temperature and humidity of the air and also on the physical conditions of the occupant. A man who has just taken a brisk exercise may find the air in the room with good ventilation to be quite stuffy; which a man in health at rest may find quite agreeable, but which to a third anæmic person, cause a sensation of draught in the same room.

The composition of average air is as follows :—

| Component | Parts per 10,000 | |
|---|---|---|
| | Fresh air | Respired air |
| Oxygen ... | 2,026 | 1,620 |
| Nitrogen ... | 7,800 | 7,500 |
| Carbon-dioxide ... | 4 | 400 |
| Water vapour (variable) ... | 150 | 500 |
| Dust and other impurities ... | (variable) | (variable) |

Though according to the theory of ventilation the presence of a small excess of carbon-

dioxide is not viewed with apprehension so far as its injurious effect on health is concerned, still, its proportion is taken as a guide for the computation of the standard requirements. With its rise in a certain system of ventilation, the proportions of the injurious bacteria in the form of the organic matter and water vapour also increase and the oxygen contents proportionally decrease. Hence, certain limiting proportions of carbon-di-oxide are taken as a basis for designing standard requirements of ventilation which are, from 5 per 10,000 parts in hospitals, 6 or 7 in residential buildings, to as much as 10, in theatres and public halls, which are crowded for a short length of time.

On the basis of this and on the assumption that an average man gives out 0.6 of a cub. ft. of carbon-dioxide per hour, it is easy to calculate that 3,000 c.ft. of fresh air must be supplied per man per hour. If the room he occupies be 10 ft. by 10 ft. by 10 ft. the air in it must be renewed three times an hour. This is, however, not strictly correct. It is not practicable to change the air completely.

It was held a few years ago that the outlet openings must be larger to cope with the larger volume of air, expanded by heat. But according to the modern sanitary opinion, if this is done reverse currents are produced; therefore it is urged to provide larger inlets.

A considerable fetish, is made by sanitary authorities in the Western countries, of draughts. So far as their cold climates are concerned, it is all right, because there is a considerable difference between the temperatures of air inside and outside their houses. The outside is very cold and the inside, heated by fire places, is hot. Hence, the effects of draughts are immediately felt. Here, in India, however, the difference is much less. Hence, draughts need not be so much feared while contemplating the provision of the means of ventilation.

From the foregoing discussion, it will be seen that ventilation consists in setting up movement in air so as to induce circulation between the fresh air out-side and the used up air inside, with the ultimate object of either diluting or removing the impurities, and at the same time producing air conditions which ensure comfort to the body.

This is effected in one of the following three ways :—(1) by taking advantage of the law of nature viz, a motion is started by particles made light by heat, rising to the top to be replaced by heavier ones sinking to the bottom, (2) by atmospheric winds or air in motion and (3) by mechanical means of artificial ventilation, such as fans or pumps which either

extract air from a room or force it into it under pressure.

In residential buildings the first two methods are employed. In the tropical climates, like that of India, where, except, perhaps, on a few hill-stations and during winter on the plains, no fires are lighted inside the rooms, the difference in temperature of air inside and outside of rooms, is, therefore, not much. On the other hand, there is almost always some wind blowing. Hence, the action of wind is the main factor to be depended upon in the regulation of ventilation. This is often rather an uncertain factor. For, whereas during a high wind especially in cold weather, a draught is likely to be produced, on still days, when the movement of air is negligible a sensation of stuffiness is sure to be experienced. Hence, the scheme of ventilation must be so designed that even on days of dull atmosphere, when the motion in air is practically nil, sufficient air-exchange between outside and inside of rooms should take place through the window space provided and when, on the other hand, there is a high wind, the draught can be prevented by partially closing the windows as necessary.

While providing window openings for ventilation in residential buildings, the habits of the people who are to occupy them must be taken

into account. Many people, especially the illiterate ones of the lower classes are in the habit of closing all the windows or even further sealing them by tacking gunny cloth on the closed shutters. For such houses the ventilation must be fool proof i. e. additional openings of such sizes and at such places should be placed that even though the windows are closed, the former will normally charge the room with sufficient fresh air. Sky ventilators in the roof, clerestory windows, bulls' eyes, floor ventilators are some of the suggestions for this. If the last named openings are to be provided, they should be done judiciously so as to avoid a direct draught on the body of the people sleeping on the floor. The latter is the practice of people in Southern India and part of the Deccan. Where, however, *charpoys* are used, no special discrimination especially in the position of the floor ventilators is required. Still such openings, intended to be kept permanently open, should be introduced at such parts of the room, where, they would not cause a sensible draught.

While providing ventilation, the following point should be noted :—

(1) The exhaled hot air is light and therefore rises to the top i. e. collects near the ceiling. If it is allowed to accumulate there for a long time, it cools again and sinks down towards the floor to be breathed again into the

lungs. Hence it is absolutely necessary to provide exit openings near the ceiling level to remove the exhaled air as rapidly as possible, while it is still hot.

(2) The scheme of ventilating a house should be so designed that the fresh air entering through the windows or other openings on the side of the house in the direction of the prevailing wind should travel from one room to another and ultimately pass through the exits provided in the wall on the opposite side. This is called "Through Ventilation". For the successful operation of it, windows must be provided also in the internal walls specially meant for ventilation though they might admit borrowed light also. For the sake of privacy between adjacent rooms of the same house it may be desirable to place them high up near the ceiling.

(3) Always remember that while over ventilation is harmless under ventilation is a positive evil. For the climatic conditions normally prevailing in India, rules of ventilation framed to suit the conditions of the Western countries are of no use. *We want more free ventilation. Draughts need not be feared so much by a person in health in this country.*

(4) The area of inlet openings should be 20 to 30 p. c. in excess of the area of the outlets.

(5) Although carbon-di-oxide diffuses in the fresh air admitted, more or less freely, the organic emanations from the breath and skin surface, do not. They hang about in corners and near the ceiling, where obstructions to a free flow of air are met with.

(6) If provision of ventilation is based on the capacity or the cubic contents of a room, the tables, sofas, movable wardrobes etc. which reduce the capacity must be taken into account.

(7) It is a fallacy that because a room is high, it must provide efficient ventilation. For the latter, the openings or orifices must be dotted here and there over the entire exposed wall surface. Otherwise, on a still day, the respired air diffuses in the large volume of the air in the high room, which causes it to cool down and thus tends to check the circulation between the inner and outer air.

## LIGHT.

We now come to the fifth principle of Domestic Sanitation viz. providing ample light in the entire house and dispelling darkness even from every nook and corner. The importance of light cannot be stressed too much. It is ingrained in every healthy mortal to love light. An infant, before the age of reason, instinctively loves light and abhors darkness. Even those

having sedentary habits and unfitted for an outdoor existence, prefer well-lighted and cheerful surroundings to darkness and gloom. Light, life and laughter synchronise, so do darkness, depression and death. Darkness is the symbol of sin. Darkness is sought by criminals for the perpetration of sinful acts. Light is indicative of piousness and purity.

Even plants become pale, droop and ultimately die if they are deprived of light—instinctively they turn to light. Similar is the case with human beings. Those who are doomed to spend a considerable time in darkness, grow pale and anaemic, lose vitality and the power of resistance to disease.

The sun's rays are the best disinfectant. Even the diffused light of the sun has this power though to a less degree. It has been proved that direct sunlight will kill even virulent bacilli of typhoid within ½ to 2 hours and diffused light, within about five hours.*

The visible light rays of the sun are, as is well known, composed of seven colours. At one end of these is the red and at the other, the violet. In addition to these there are invisible rays—those at one end are called infra-red, and those at the other, ultra-violet. The infra-red include the invisible dark rays of heat. The

* Hygiene and Public Health by B. N. Ghosh.

ultra-violet rays are very powerful in destroying bacteria and possess therapeutic value to a remarkable degree. The cells of the skin and corpuscles of the blood, circulating in the veins and arteries close to the skin surface, absorb these rays and as a result the blood is purified and its circulation accelerated, which causes a feeling of vigour and health to be experienced.

Dr. Rollier of Switzerland has, of late years, proved beyond a shadow of doubt, the wonderful healing power possessed by the sun's rays, by treating successfully hundreds of cases of tubercular affection, which were declared to be beyond hope of cure by the usual means. He has built special sun pavillions called "Solaria" on the top of a hill, at Leysin, Switzerland, with special means of regulating the intensity and dosage of the sun's rays.

Very often these rays are absorbed by the water vapour, smoke, dust, etc. present in the atmosphere. Hence, it becomes often difficult to make full use of the sunlight as a therapeutic agent, especially in crowded cities. Again, many countries in Europe, as for example, England, are not blessed with sunshine for any considerable period of the year. Hence, ultra-violet rays are produced artificially by passing electric currents through mercury vapour or by some such suitable devices; but the expense

is pretty high. In India, however, we are blessed by Providence with so much free sunlight almost all the year round. Hence, there should be no necessity, especially for those who cannot afford it, of resorting to the artificial means of producing ultra-violet rays.

The ancient custom of annointing the body with cocoanut or mustard oil and basking in the sunshine has almost sunk into oblivion with the advance of modern civilization. But it possesses a good many virtues to commend itself for a revival especially for the benefit of the young children particularly suffering from rickets, which are wonderfully cured by exposure to sun's rays or ultra-violet rays. The annointment with oil serves a treble purpose. Firstly, the vigourous massage which is usually done with the application of oil tends to accelerate the circulation of blood; secondly, the oily surface prevents sunburns by reflecting away the heat rays and thirdly, it absorbs the ultra-violet rays.

"The sun's magic rays heal all that they come in contact with. They repair broken down bone tissue; they dry up running sores and ulcers and cause new skin to grow over; they cause swellings to subside; they alleviate pain; they bring down temperature, diminish the drenching sweats and decrease cough.

The sun is the greatest of all natural healing agents in consumption." *

The foregoing facts, specially mentioned rather in detail will convince the reader of the vital importance of natural light on the health of human beings; therefore, a house should be so built that every room should receive the sun's rays in some part of it, some time or other, during the course of the day; and there should be no corner in the entire house which is not sufficiently lighted. Darkness is synonymous with dirt. If a room is generally dark, it is sure to be dirty. Even in a room lighted moderately well, the darkness in the corners and recesses is sure to conceal dirt and dust. A housemaid's broom is bound to fail, in its circular sweep in corners, to penetrate into the depth of the recesses to clear the dust and dirt away. All sorts of visible vermin and microscopic bacteria breed there with unchecked activities as the darkness envelopes them. If on the other hand, there is light in such corners and recesses, it makes the dirt visible and none but the most careless person will consciously allow it to accumulate there.

---

* Dr. EDWARD PARLSKY, M. D., Brooklyn, New York.
by acknowledgment to 'Health' Sept. 1934.

# DOMESTIC WATER SUPPLY.

Next in order of importance to air, water is another prime necessity of life. Life cannot be sustained even for a few minutes without air; without water, it can be sustained for a longer period, still death is sure to ensue.

Water, from whatever source it may be coming e. g. a river, a lake, a spring or a well, is all originally derived from the rain. The water as it comes from rain is distilled by nature and is very pure, but as it falls on the ground and flows along or under it, it collects impurities. The latter are either suspended or dissolved. The suspended impurities can be removed by treatment with alum or filtration.

The dissolved impurities in water are again of two kinds:—(1) mineral and (2) organic. The latter, again, are subdivided into vegetable and animal.

The mineral impurities render the water hard. This is due to certain salts of Sodium, Calcium, and Magnesium dissolved in it. The hardness due to chalk or Calcium Carbonate can be removed either by boiling or by mixing lime water in it. But hardness due to other salts cannot be so easily removed. The disadvantages of hardness are that *dhals* (cereals) and vegetables cooked in it do not become

tender; hard water is, again, bad for washing purposes, because, lot of soap is wasted first for removing hardness before it cleans dirt. It is believed that stone and gravel are produced by it in the bladder. Hard water does not dissolve soap freely without curdling; that is its test.

Palatibility, or the sparklingness of water is not due to the presence or absence of any salts but to the oxygen and carbonic acid gas dissolved in it. All waters which are pleasant and sparkling to taste are not necessarily pure. The waters which are brakish contain mostly sodium chloride or common salt and to a certain extent other salts. Common salt does not, in itself, make the water hard, but it is generally associated with other salts which render it so. Hence, brakish waters should not be used, especially, by the dyspeptics and generally by those suffering from any intestinal disorders.

So far about the mineral impurities, some of which though harmful to health are not, on the whole, dangerous. But the effects of organic impurities are very serious and often lead to the outbreaks of diseases in the community, which are called epidemics. By far the most common source of organic impurities is sewage either by soakage from leaking drains, manure pits, muckheaps, latrines etc., getting into the source of supply, whether it be a well,

or a stream. Often, bodies of dead rats, mice, cats, dogs, etc. float and decompose in water. All these make it very dangerous for drinking purposes.

When a disease in an epidemic form breaks out, it must be due to some poison either in food or water. Poison in food may affect one isolated family sharing it commonly, but as it spreads to different families, it is a sure indication of the common water supply of the community having been contaminated. Such spreading diseases are, Diarrhoea, Cholera, Typhoid, Dysentery, diseases of certain parasites, e.g. guinea worm etc. The latter enters the body with drinking water, remains inside it for a year, after which, it breeds and makes itself felt in a swollen foot or leg.

## SOURCES OF SUPPLY AND HOW THEY ARE CONTAMINATED.

Household supplies of water are derived in India either from a river or a small stream, a tank, wells or springs. In very rare cases it is derived directly from rain and stored for household use in any large quantities.

Water from rivers and streams, should always be looked upon with suspicion. In many instances the sewage from large towns is let into them. Hence, smaller the volume of

water in the river, the greater the quantity of sewage contamination, and the nearer the place from where the water is drawn for use to the source of contamination, the more dangerous the water becomes for domestic purposes. Even small streams and nallas or surface water from fields, though they do not receive sewage directly, are still likely to be contaminated by the excreta of animals including human beings, dead bodies of fish, decomposing vegetation etc. which are likely to contaminate it.

However, as the rivers and nallas flow, the contamination decreases; because there is a process of self-purification involved in the career of running water.

This might be due to the fish and other living organisms in water eating out the organic matter, or to the process of "oxidation" or the destruction by oxygen in the air with which the water comes in contact in the course of its flow. But it is a fact that a few miles below the place where sewage is let into the river, the water becomes quite pure again. This, however, cannot be entirely relied upon as we do not know the other sources of contamination in the intermediate length.

Tanks and reservoirs collect only rain-water flowing along the ground surface and therefore,

so long as we are not sure that there is no source of contamination from human habitations or cattle in the entire catchment area from which the rain-water flows into them, purity of supply cannot be guaranteed. On the contrary, the smaller the tank the greater the chances of contamination.

*Wells*:—Wells are classified into two divisions:—(1) Shallow wells, (2) deep wells. A well is called deep, not necessarily because it is deep, but because one or more impermeable layers like black earth, intervene and prevent the water percolating through the ground surface from reaching it. A shallow well is one which derives its supply from such percolation. In India, with the exception of some of the larger towns, the supply of water for domestic supplies is derived from wells. In some towns and villages there is a well in every house, some inside the house, and some a little away from it, mostly on the rear side. When these wells are first excavated the supply is pure, but gradually sewage and the sullage water, which, from the surrounding houses is allowed to soak into the ground gets filtered through the soil and finds its way to the well. It is at this time pure, but as the underground strata are gradually polluted and get saturated with the organic impurities in the sewage, the filtering media lose their power of filtration

and the liquid sewage passes unfiltered to the lower and lower level, and ultimately reaches the water bearing stratum from which the well draws its supply, in the form of pure sewage, making the whole supply dangerous for human consumption. If the well is deep in the above sense, the intervening impermeable layer or layers effectively bar the sewage from entering the water-bearing strata and contaminating the supply.

Even if a well is deep with an assuredly pure water-supply, the latter is likely to be contaminated by one or more of the following causes:—

(1) Very often, there are trees overhanging or in close proximity of the well and the leaves, flowers and fruit from it either drop directly or are blown by wind into it, which decompose and contaminate the supply.

(2) Very often washing or bathing is done quite close to the well and the dirty water splashes into it.

(3) There is no well-built properly graded gutter for the waste water to flow away from the well. This causes the water to stagnate in a pond quite close to the well and it percolates into it.

(4) Very often steps are provided to reach the water in the well. Many people go along

them and indiscriminately pollute the water by washing hands and feet and even by spitting or gargling the mouth into it. Burnishing copper or brass pots with ashes and earth, often road scrapings, and washing them in the well, is also a common practice.

(5) The village urchins often bathe and swim in the wells.

Thus wells in the midst of human habitation should be looked upon with suspicion unless they are deep in the technical sense of the word and vigilently guarded against in respect of the above common sources of impurities.

The wells which are open to the sun and air are preferable, no doubt, but when it is considered that open wells are likely to be polluted in the way mentioned above, it is always advisable to close the wells and leave an aperture just sufficient for drawing water or close them altogether and instal hand pumps for drawing water. This will incidentally prevent mosquito-breeding. Means should, however, be provided for opening the cover for occasional æreation, cleaning and repairs of the well.

Deep bore holes drilled into the ground to tap under-ground water have always a supply of pure water.

A spring is an outflow of a supply of water situated somewhere at a higher level, from which it flows or percolates by gravity to a lower level, through a subterrenean path. During its passage it gets filtered and hence it is invariably pure. Unlike water from deep bore-holes, it gets a chance of æration and is also palatable.

## PURIFICATION OF WATER.

The dangers attendant on the indiscriminate use of water from rivers, nallas and wells situated in the midst of human habitation, have been dealt with in the previous chapter. Prevention is always better than cure. Hence, it is safe to use water from doubtful sources for cooking and drinking purposes only after it is purified. We are discussing here only the methods on a small scale suitable for domestic supply.

The best and surest method is distillation. But it is expensive and also impracticable. It is possible, however, to collect rain-water in the monsoon season sufficient at a time for 2/3 days requirement to meet the breaks in the rain-fall. It may be either collected directly from house roofs as at Broach, or similar large surfaces, or from fairly pure ground such as sand or unmanured field as at Aden, away from human habitation. This should be done after

the roof or the ground has been thoroughly washed away. For, the first flow from rain, collected from roof surfaces besides containing impurities such as, particles of dust, soot, droppings of birds, leaves of trees, pollens of flowers etc., also holds acids and ammonia in the atmosphere dissolved in it. To remove the former the water collected must be well strained through several folds of cloth or better through a sand filter. The latter impurities are harmless.

Rain-water is very soft and is specially useful for washing purposes. A very small quantity of soap is required. In some countries notably in Holland, concrete or masonry tanks of several months consuming capacity are constructed and rain-water is stored in them.

The second best method which is more practicable for every household is to boil the water required for drinking purposes. For perfect purification the boiling water must actually ebulate for at least 5 minutes. Though the living organisms in water stand much higher temperature than that of the boiling water, they are killed by the moist heat or saturated steam at the boiling temperature. Hence boiling is an effective remedy. We have already seen mere boiling is not effective in removing hardness of water except that due to the presence of chalk. The third remedy is to

filter the water. Filters if working efficiently remove both the suspended and the dissolved impurities. In respect of the former the action is purely mechanical, the voids in sand or the pores in other material like coal, etc., offer resistance to the suspended matter which is arrested by them and only the pure water allowed to pass. In respect of the organic matter the action is chemical. The upper layer of the filtering material holds a sort of bacteria which eat out all the organic matter in the water, but in the course of a few days the layer becomes clogged and the filter does not work. The sand or whatever other material it is, must then be washed for re-working of the filter. When the pores in the upper layer are clogged not only does the filter not work well, but it forms a positive danger; because the growth of fungus occurs on it which makes the water worse than before. Hence absence of a filter is better than a dirty filter.

The materials commonly used for filtration are sand, gravel, iron filings, charcoal, animal coal, porous stone, ground slag etc. Sand is by far very common. For efficient working three grades should be used. The lowest should be of shingle of ½ inch size, the middle layer of gravel of ¼ inch size, and the upper layer of very fine sand. All these should be carefully washed separately and then used. Ordinarily

filters should be washed once a week. After washing the material should be exposed to sun for a day and fresh one used. The old material should be screened, graded, and used again next week.

Not only the sand or the other filtering material, but the pots used for holding the filtering material and the filtered water, should also be scrupulously cleaned, the former, every week along with filters and the latter every day.

## PURIFICATION BY CHEMICAL AND OTHER AGENTS.

*Alum*:—This has no germicidal action; it combines with the alkaline carbonates present in water to form aluminium hydrate, which being insoluble in water precipitates to the bottom.

The fruit of the "clearing nut" (*Nirmali*) is frequently used in India for the same purpose. The fruit is rubbed against the inner sides of the vessel holding muddy water for a minute and in a few minutes the suspended impurities settle down at the bottom leaving clear water above.

*Potassium Permanganate*:—This does not directly kill bacteria, but destroys the organic matter on which the bacteria live. Still, this

is a very sure, cheap, and simple remedy of disinfecting well-water during periods of epidemics. When dissolved in water it produces nascent oxygen which oxidises organic matter.

There are two methods of using it. The first is to calculate the quantity of water in the well or the cistern to be dis-infected, and put potassium permanganate into it in the proportion of five parts per million parts of water. The other depends on the colour test only. A sufficient quantity is said to have been added when after half an hour a red colour is still present. If not, add more. In all cases enough should be added to produce a faint pink clour lasting 24 hours.

The mode of mixing P. P. is as follows: Put the crystals of P. P. in a bucket and fill it nearly half with the water to be treated. Stir it up and pour the red solution thus produced into the well, leaving the portion of the P. P. that is not yet dissolved in the bucket at the bottom. Lower the bucket into the well, fill it with water, draw it up, stir it, and pour back the red solution as before. Repeat the process till all the P. P. has been dissolved. One to six ounces will be generally found to be sufficient for average wells. If the P. P. is added at night the water will be fit for drinking on the following morning. If at this time the

water has a red colour it will have a slightly unpleasant taste, but it is perfectly harmless. The unpleasant taste, will go away automatically in course of time as water is drawn from the well.

*Bleaching Powder*:—This is a whitish grey powder with a characteristic smell. It consists of slaked lime saturated with chlorine and is a powerful sterilising agent. The powders available in the market are of varying strengths in respect of the chlorine contained. Again, the dose of the powder required to sterilise a certain quantity of water depends on the amount of the organic matter present. Roughly one part of bleaching powder of 25 p. c. chlorine strength is required to sterilise one million parts of average water. According to this one ounce of bleaching powder (25 p. c. strength) would be required to sterilise water five feet deep in a well of 8 ft. diameter.

Make a solution of one ounce of powder dissolved in one pint (20 ozs.) of water, and keep it in a well stoppered bottle in the dark. The well treated with it should be allowed to stand for 24 hours for its action.

The test of the sufficiency of dose is that there should be a free chlorine in it which should be appreciable to the taste. The presence of free chlorine can be tested also chemically by adding Potassium Iodide and starch

to the sample of water when a bright blue colour will appear.

*Chlorogen* :—This acts in the same way as the bleaching powder, by liberating chlorine and nascent oxygen which are both very powerful sterilising agents. Chlorogen deteriorates in strength on keeping for a long time. The amount of chlorogen required depends on the degree of contamination. Hence, a thumb rule can not be applied for its use. The method of determining the quantity of chlorogen to treat a certain well is rather complicated. Roughly, if a perceptible taste of chlorine is felt after 12 hours in the water treated, we err on the safe side.

# HOUSE CLEANING.

If one starts to clean a house from one end, before one reaches the other, the former is again ready for cleaning. We have thus to wage a war continually against dirt, and our enemy is such that it is imposible to completely vanquish him. At the most we can keep him under control. The moment of our rest is the moment of our defeat. Nevertheless, if a habit of perfect cleanliness is once acquired it becomes second nature and the very sight of dirt becomes unbearable. There is some indescribable pleasure—a sense of supreme satisfaction arising from cleanliness, and the person who has once realised it, becomes so sensitive to it, that he feels a sort of positive discomfort at the sight of dirt.

A house may have been designed and built on the most up-to-date hygienic principles, with the best of materials, and supplied with every ultra-modern appliance of comfort and convenience, but if it is not maintained in a clean state, it may soon be rendered unfit for human habitation. Hence, cleaning the house both inside and outside is a matter of utmost importance.

Prevention is always better than cure. If therefore, every one in the house would do his or her bit, not necessarily in cleaning, but by preventing dirt by the practice of cleanly habits, it would go a long way towards success. Even young children should be trained to do so from their early age, which then becomes a part and parcel of themselves.

Method and system are, as in every thing else, the key-note to success in this matter also. They consist in having a clear idea of what is exactly to be done, and in pre-arranging as to when, how, and by whom exactly it has got to be done. If the person concerned is made to feel his or her responsibility, success would be guaranteed. An important point is the division of labour. There is nothing derogatory or undignified in doing part of it oneself. On the contrary, if the important person in the household shows occasionally a keenness on doing it personally, every one else in the house catches the spirt of dignity of labour, and the servants, too, do not get an opportunity to scamp work.

In order to maintain a house and its premises in a perfectly clean state, certain rounds of duties have to be done daily, weekly, monthly, and periodically. As a general rule, daily work must be directed towards removal of fresh dirt, which is continually collecting on

surface, and the weekly and periodical cleaning must aim at restoration to that condition of perfect cleanliness, from which everything around us tends continually to depart.

Out of the daily duties sweeping dust and collecting, removing and disposing of the refuse produced inside and outside the house is an important one. Dust must be removed not only from the floor, but from every surface which is likely to collect it, such as wall surfaces, picture frames, furniture etc. First, take out the door mats and carpets away from the house shake and beat them with a stick, then close all the doors of the room to be cleaned so that the dust may not enter other rooms, sweep the floor, then spread the carpet again in position, wait for a few minutes for the dust to settle down and then dust the pieces of furniture etc. The usual practice of doing the latter consists of beating the surface briskly with a piece of cloth tied to the end of a rod. This does not remove the dust, but helps to distribute it evenly on the surrounding articles in the room. The proper way of doing it is to wipe the dust off gently and carefully with a piece of moist cloth which should be shaken frequently out of the window.

The rooms used most are likely to be most dusty. The main entrance passage is thus the worst in this respect, then comes the staircase,

if one there be on the front side, because, it is the only thoroughfare for going up. It was formerly the custom enjoined by the Hindu Shastras to wash one's feet with water before entering the house. For, if we walk out of doors we are sure to bring in with our feet, some of the dirt on the street. What this dirt shows itself to be under a microscope, has been already described on page. 210. It is a pity, however, that many of us, in blind imitation of the Western people, enter even the innermost apartments with shoes on. The dust from the entrance passage and stairs which is full of harmful bacteria, must not be allowed to enter other rooms. These rooms should be cleaned first in the morning after closing the doors of the adjoining rooms.

As a general rule all living rooms should be cleaned daily. The bed room in which we pass nearly 1/3 of our life should be kept particularly clean. They should be sunned every day by opening out windows and admitting sun's rays especially in the morning if this be possible.

The stairs should be started from the top downwards, but not in a manner as to push the dust by a brisk sweep of the broom. Every step should be wiped gently with a broom or better still with a round brush which penetrates into corners better, and the dust from it collected in a pan held below the edge.

All the ledges in doors, windows, etc. should be wiped clean; lamps, flower pots, ornaments forming articles of decoration etc., should be wiped, rubbed, and polished.

Beddings and coverings should be aired every day for few hours and sunned once a week together with the bed taken to pieces. A searching examination should be occasionally made of joints, folds, etc. to search if any bugs have intruded, and if so, prompt action should be taken to inject kerosene oil emulsion,* then close the joints with wax, and throw insect powder to destroy their eggs.

Emptying slop basins or cisterns should also form one of the daily rounds of duties. All the open drains should then be examined and obstruction, if any, removed.

Among the weekly duties come the sweeping of the wall surface, corners and ceiling etc. removing cob-webs and dust, washing floors urinals, and sinks with a disinfectant, and scrubbing and washing shelves in the kitchen cupboards.

Household dust bins should preferably be of iron and they should be disinfected by burning waste paper in them.

Bath and toilet rooms should be white-washed twice a year. If freshly slaked lime

---

* Please see under cheap disinfectants. Page 250.

is used, it behaves as an excellent disinfectant. If trouble of bugs is apprehended, the bed rooms should be given a buff wash made of freshly slaked lime mixed with *Multan Mitti* or some such cheap colouring pigment, so that it can be renewed at a small cost from time to time., with a view to kill all the vermin.

Kitchen walls of the houses of the middle classes in which fire-wood is mostly used for fuel are likely to be dark on account of the smoke. The best plan is to give a cheap yellow lime wash or better still, two coats of a paint prepared in the following manner :—

Pour water on freshly burnt Surat lime (lime prepared by burning sea shells in a kiln) to make a wash of the consistency of cream, mix boiled linseed oil with it in the proportion of one part of linseed oil to 8 parts of the milk of lime and give a wash with it by means of a vegetable fibre brush, as lime will act on animal bristles and soon destroy the brush. The surface when dry can be frequently washed with a disinfectant without losing the colour. This paint lasts for a long time.

# A FEW CHIEF DISINFECTANTS AND THEIR USE.

From personal knowledge the writer is led to believe that even many educated people have got a wrong notion about disinfectants. Many people think that a substance which conceals or destroys an offensive stink emanating from decomposing matter is a disinfectant and with this mistaken idea they entirely rely upon them under a delusion which gives them a sense of false security. It is therefore proposed to close this section after making a brief reference in this chapter to a few cheap and reliable disinfectants.

*Disinfectants* are agents which destroy the germs, or the carriers of the germs, of disease, and should be distinguished from the *antiseptics* which merely check the growth of the germs and prevent animal or vegetable substances from decomposing, and from *deodorants*, which oxidise the products of decomposition as soon as they are produced and so absorb or distroy offensive smells.

It is not enough to know that a certain substance is a disinfectant; the quantity to be used and the degree of concentration necessary for its successful operation are also important factors.

(1) *Fresh* air and *sun-light* are the natural disinfectants and kill germs of most diseases. The only disadvantage is that whereas clothes, mattresses, pieces of furniture and other movable articles can be exposed to sun-light, and disinfected, the corners and recesses of rooms can not., for which some other convenient disinfectants have to be sought for. For systematic disinfection by sun-light the following rules should be observed:—

Select a flat piece of ground with no cracks in it. It should preferably be sandy or else sand may be sprinkled on its surface.

Let it get hot by exposure to sun. Thus disinfection should not be attempted before 11 o'clock in the morning.

Spread clothes on it evenly in a single layer. If they are left exposed to sun in this way even for an hour that is enough. Thick padded clothes such as quilted coats, mattresses etc must be turned once or twice over so that both the sides are well heated. Beds and pieces of wooden furniture should be taken to pieces if possible, and exposed to sun for several days.

(2) *Quick* lime is the next best agent for disinfection. It is cheap and has a very high germicidal value. Water should be sprinkled on freshly burnt kunker, till it falls to powder, which is called slaked lime. This may be used

either in a dry state or formed into a liquid of the consistency of milk by dissolving it into water, and then used in that condition. It can be used to purify water, to disinfect floors, stables, drains, gutters etc. The powder soon absorbs carbon-di-oxide from the air, and deteriorates in quality.

(3) *Kerosene Emulsion*:—This comes next in point of cheapness and convenience for household use. The method of preparing it is this:

Take bar soap 5 parts by weight and boil it in 15 parts of water. To this should be added gradually 100 parts of kerosene oil stirring it up all the while. This makes an excellent disinfectant; 1 in 1000 dilution with water kills fleas in two minutes. For disinfecting floors, walls etc 1 in 20 solution should be used.

(4) *Phenyle*:—This and carbolic acid are both obtained from coal tar, but phenyle is twice as powerful as carbolic acid besides being much cheaper. It is, however, poisonous and irritant to the skin, one part of it in 50 parts of water forms a good disinfectant.

(5) *Izal* is also obtained from coal-tar. It is non-irritant, non-poisonous and cheap, and thus is superior to phenyle in every respect. 1 of it in 500 of water disinfects even the stools of a Typhoid patient, in 15 minutes. (Dr. Klein).

(6) *Pesterine* is a strong disinfectant and comparatively cheap. It does not mix with water but does so freely in soap solution. The objection to its use is that it stains fabric. 1 part in 100 of water makes a sufficiently strong disinfectant.

(7) *Fumigation by sulphurous acid.* This is also a very effective and comparatively cheap method, and possesses some special advantage over other disinfectants in so much as it kills all the germs floating in the atmosphere contained in a room. But as it is a poisonous gas it can not be used when the room is occupied. There are special machines designed for this purpose, but the pot method is the cheapest and easiest for household use.

First take powdered sulphur in the proportion of 2 lbs. per 1000 c. ft. capacity of a room, moisten it with methylated spirit, and put it into an iron pot. The latter should be placed into a tub containing water. The tub should be placed high up in the centre of the room, say at 5 or 6 ft, above the floor. Before igniting the sulphur, all the doors and windows etc should be closed. Even the chinks and cracks in them should be closed by pasting paper on them. Then ignite the sulphur and let the smoke emanating from it fill the room for six hours, when the doors and windows should again be opened.

The water is required for supplying the necessary moisture to produce hydrated sulphur-di-oxide ( $SO_2$ ) and it is to be burnt at a high level because, the sulphur gas being heavier than air will sinks to the bottom and will not reach the higher parts of the room.

Ready-made sulphur candles can now be had in the market for this purpose which are very suitable.

While using sulphur as a means of disinfectant it should be noted that its gas bleaches all colouring matter of vegetable origin, acts on cotton and linen fabric, and attacks all metals especially silver, which it stains very badly.

As a general rule disinfectants act better at high temperature. The water to be used should therefore be hot. Hard water interferes with the property of disinfection. Hence, only soft water should be used. Again an emulsion is more powerful than a mere solution.

A bucket spray pump does the work of disinfecting very satisfactorily and economically.

# REPAIRS AND ALTERATIONS.

The subject of repairs is so vast that in order to do full justice to it, a volume, perhaps bigger than the present one would be required. In the present chapter it is proposed only to touch the aspect of remodelling a building, which is in need of repairs with a view to improve the general sanitation connected with it.

From this point of view an examination of the existing drainage system occupies the first place of importance. A defective drainage, whether closed underground, or open at surface, makes itself visible, first in the evidence of damp, and then in that of a stink. This may be due to a crack in the drain, or some obstruction in the passage of the water flowing through it, which causes the water to head up, soak in the ground and overflow, if it gets an outlet. The stink even inside the bath rooms in Indian homes is so bad sometimes that it is on ordeal to stand there for a few minutes. Even flushing the bath room with a copious supply of water does not remove it. The reason is that the obstruction which chokes the drain is in a state of decomposition and the foul gases given out by it enter the room and cause the stink.

The first precaution against this is to provide traps at every drain in the house, so as to cut off the connection between the interior of the house with the outside drain. A *Nhani* trap has already been illustrated on page 202. In places where a water-carriage system has been introduced, the municipal authorities compel the owner by law to provide systematically designed drains with traps, ventilating pipes etc., but even in places where a system of surface open drains exists, provision of traps would do a lot towards improving the general sanitation. The next thing is to give a suitable fall to the drains so as to create a self-cleansing velocity in the flow, and the third essential is the provision of means of access to the drains for inspection or repairs if the drains be wholly or partially covered underground. This subject has been treated at considerable length in the author's Modern Indian Houses etc.

80 p. c. of the damp is caused by defective drainage; 15 p. c. by leaky roofs, and only 5 p. c. by all other causes combined. In the case of flat roofs a not uncommon cause of damp is the neglect of the periodical inspection and repairs of the cracks on the surface of the terrace and in the brickwork and coping of the parapet walls. The damp due to these causes is visible by stained patches on the surface of upper walls.

The following are the remedies suggested for this :—

(a) If the roof be of mud and if impervious white earth be not available, leep the surface with a mixture of 12 parts of roofing earth, 4 of cowdung and one of cement mixed in water, and moderately rub the surface with the mason's trowel. This will, in most cases, be found to be effective, but if it does not stop the trouble, apply, when the surface is dry, a coat of the paint prepared of sodiumised clay mixed with boiled linseed oil.

(b) If the roof be of cement or lime concrete terrace, and if the cracks are very fine called hair cracks then,

(1) give a coat of cowdung, cement, and fine sand mixed in equal proportions mixed in water with a brush. This should be applied in the evening so as to give it a chance of setting slowly.

(2) Paint the cracked surface with hot bitumen, or cold "Colas" the remedy is effective but it stains the surface dark.

(c) If the cracks are wide,

(1) Take linseed oil two lbs. and while it is being boiled add one lb. of resin crushed to powder and then powder-

ed bath brick or very fine sand one lb. and apply the mixture with a brush while hot.

(d) If the cracks are big, widen them further by means of a chisel, remove every bit of loose matter and wash them clean with water. After this fill in by pushing hard by the edge of a trowel, a mixture composed of cotton cut to pieces thoroughly soaked in hot asphalt or bitumen, spread some sand on the surface and wipe it off.

Another item of frequent repairs is the plaster. If it be of lime a very careful treatment is required, because, it is very difficult to make a proper junction between the old mortar which has already set and the fresh mortar. Open all the loosened patches, rake out the joints, soak them freely with water and then apply lime mortar in which, cement is mixed in the proportion of 5 of mortar to 1 of cement. This would make the surface sufficiently hard in about 6 to 8 hours, when it should be tamped closely with an edged instrument and then a final coat consisting of cream of lime and fine sand in equal proportions ground to a workable paste with a pestle on a flat piece of stone, applied with a trowel and polished.

If the plaster be of mud dismantle the patch which sounds hollow, moisten the portion

with water and replaster it with sodiumised clay or brick clay in which, is mixed, cement in the proportions of one of cement to 12 of clay. This should be indented as described above and finished off with a final coat of the same material.

Another item of repairs, which is often very troublesome, and causes damp and consequent ill-health is the leak through the walls and floor in the cellar or basement floor. The entire surface of the wall and floor should be minutely examined under the light of an electric torch if the daylight be insufficient, to see whether any cracks are visible and water leaks through them and if so they should be treated in the manner described for repairing leaky terraced roofs. If there be no cracks and the water is seeping through the pores of the permeable concrete the remedy suggested on page 208 viz excavating a trench on the outside of the wall, in the portion through which water leaks, pointing the joints with cement, and in addition, filling the trench with black cotton soil well rammed, may be resorted to, or a coating of cement plaster may be applied.

If the floor of the basement is seeping it is rather a difficult job to set right, because, the water coming inside is in most cases under pressure. Any surface treatment, therefore,

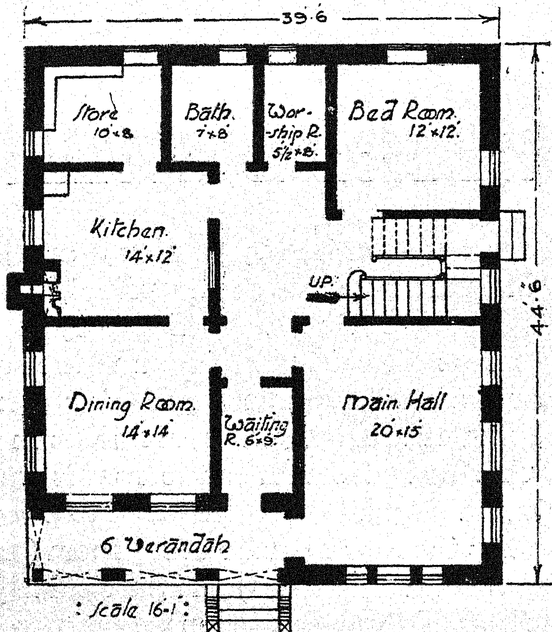
is of no use. The only satisfactory remedy is to construct a new floor on the top of the old one, with cement concrete, taking all the precautions to ensure a compact and water-tight surface.

# TYPE ECONOMICAL PLANS.

A few economical type plans are given below illustrating some of the principles mentioned in the foregoing pages. Economy consists of two sorts: first in planning and the second in construction. Economic planning consists of grouping of the different apartments in such a way that no space under the roof is wasted, a minimum possible being allotted to passages and lobbies in order to make every room (except perhaps the drawing room) and particularly the bath room and services, independently approachable. This has been attempted to be done in the few plans given below.

The plans are self-explanatory, still for the guidance of laymen who have never seen building plans, explanation of the details is supplied in the key plan in fig. 55.

The costs given at the head of each plan are based on the rates prevailing in an average town in the Bombay Presidency. When the rates in average towns in the different provinces are compared, it is found that these are 5 to 10 p. c. in excess of those in the Central,




: GROUND FLOOR PLAN :

Fig. 55.

A, A, (Diagonal dotted cross lines), indicate arches; W, W, (Double lines along walls near the outer edge), windows; C, C, (Recess in walls), cupboards; D, D, (Breaks in walls), doors; St, staircase; CH, chulla; S, sink; SF, Shelf; B (Rectangular fig. in bed room), position of bed. N, (The arrow on the right, in the front). Shows the North direction. The present plan faces West.

United Provinces and the Punjab, and about 15 p. c., of those in the Madras Presidency. An idea of the rates assumed can be had from the

complete estimates of two buildings given. Another purpose of the estimates is to give a layman an idea of the various items in building construction in order to enable him to pre-arrange for materials and funds.

Wherever pitched roof is indicated roof lines have been shown in dotted lines on the plans. As the plans are intended for upcountry places latrines are expected to be built a little away from the main building. They are therefore not shown. The cost includes the main building only. Site, out-buildings, compound wall, etc. would require an extra amount.

## PLAN No. 1.

**Plinth Area. 1170 sq. ft.]** **[Cost Rs. 1800.**

Very often the sites for buildings, lining streets in towns are long with a very narrow frontage, and further, the side walls of the houses, either touch each other or there are no separate side walls to each house, but one wall serves the common purpose of two adjecent houses. Under such circumstances it is impossible to derive light from the sides. The plan in figs. 56 to 58 shows how this difficulty is overcome and how by skilful designing maximum light and ventilation can be secured.

Fig. 56.

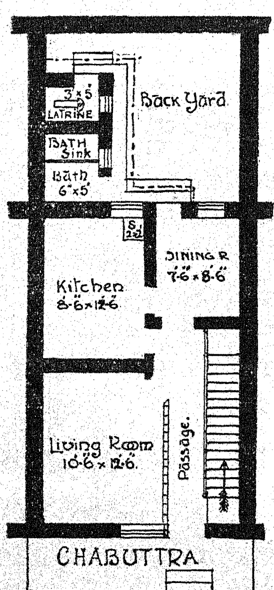
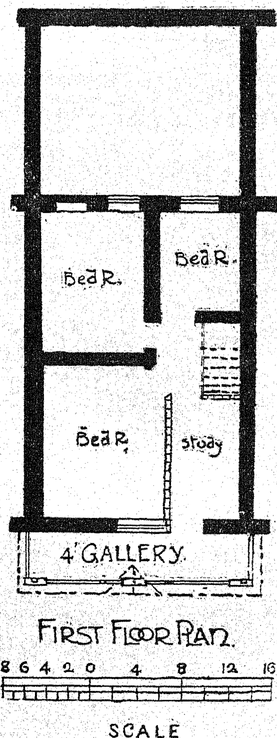



Fig. 57.



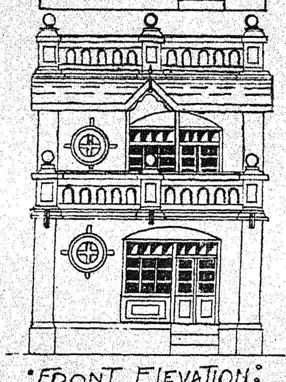




Fig. 58.

There is an open porch or *chabuttra* in front. If this is enclosed by a low compound wall it can be used as an excellent conservatory. Of course, only dwarf varieties of plants must be grown otherwise they will darken the drawing room by shutting off light partially. As one enters the front door there is on the left side a drawing room well lighted by the large window on the front side. Behind it is the kitchen which has to be contracted a little to make room for the dining room. The kitchen is lighted by a window from the back side. On the rear side there is a closed bath room and a latrine, the latter has an opening on the opposite side in order to lessen the trouble of flies, should the door remain open by chance. The stair case in the front is 3 ft. wide and is very easy to ascend.

Upstairs (Fig. 57) are three bed rooms, a study room and a projecting gallery in front. All the rooms are so skilfully grouped that each has an independent entrance and the gallery, which is an excellent sitting out place, is independently accessible from every bed room. Thus every inch of the space available has been utilised for living accommodation.

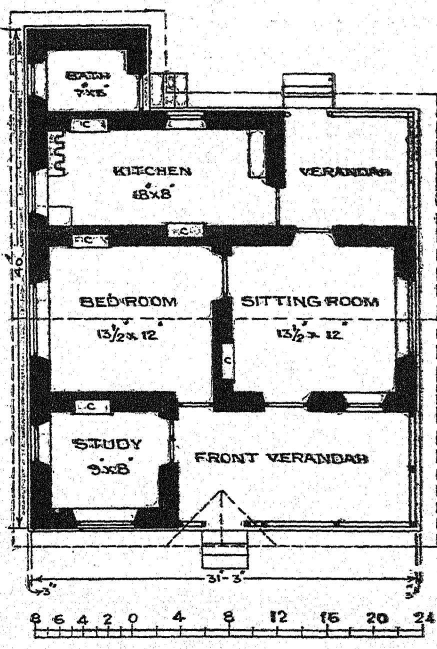
The elevation (Fig. 58) is smart and attractive, but if there are a number of such houses on

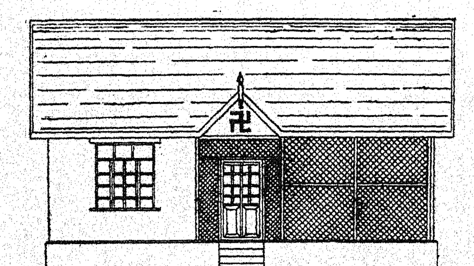
the street, in order to break the effect of deadening monotony many alternative forms in pleasing diversity, can be adopted.

## PLAN NO. 2.

**Plinth area 1088 sq. ft.]** **[Cost Rs. 1550**

This small but simple and attractive countryside building combines economy, comfort and convenience in one place. The verandahs are an Indian institution and no house, though small, is complete without them. The present cottage has them both in the front and rear and as they are closed by a trellis work which admits light and breeze, they constitute delightful sitting out places affording the best privacy. The study room in the front can be used also as a bed room. The two central rooms are spacious and the very wide windows provided in them give them a feeling of light and airiness. The elongated kitchen with two windows, a sink, a shelf and a cupboard with a wide verandah in front should prove a constant pride and joy of the housewife. It would ordinarily provide the necessary accommodation for the members of the household to dine together. The front verandah which is 9 ft. wide, would accommodate at least 5 beds and still leave sufficient room for a passage.



FRONT ELEVATION

Fig 59 & 60.

The distinguishing feature of the cottage is its cheapness. In spite of the provision of a damp-proof course, rat proof construction, fully glazed windows, concrete floor throughout, leak-proof roof of corrugated sheets etc. the building costs only Rs. fifteen hundred and odd. The detailed estimate attached will convince the reader of it. The rate per sq. ft. of plinth area works out to Rs. 1/8. For preventing heat of the roof one of the remedies suggested on page 165 might be adopted.

---

## Abstract of quantities and cost of plan No. 2.

| Item No. | Name of Item. | Quantity | rate Rs. A. | per unit | amount. Rs. |
|---|---|---|---|---|---|
| 1 | Excavation in average soil. | cft. 1667 | 0–12 | cft. 100 | 12·51 |
| 2 | Filling foundations with boulders and rubble in mud. | cft. 1250 | 5—0 | ,, | 62·50 |
| 3 | Rubble Stone in mud masonry for plinth including cement pointing to the outer surface above ground. | cft. 1375 | 7—0 | ,, | 94·71 |
| 4 | Damp-proof Course of $\frac{3}{4}$ inch Cement, sand and coaltar. | sq. ft. 338 | 9—0 | sq. ft. 100 | 30·42 |
| 5 | Filling earth in plinth. | cft. 1831 | 0—8 | cft. 100 | 9·16 |
| 6 | Superstructure of pise earth. | cft. 2606 | 3—0 | ,, | 78·18 |
| 7 | Flooring of broken brickbats and lime concrete surfaced over. | sq. ft. 750 | 9—0 | sq. ft. 100 | 67·50 |
| 8 | One inch flag stone paving in lime. | sq. ft. 108 | 10—0 | ,, | 10·80 |
| 9 | Doors teak or sal wood plain planked with iron fixtures. | sq. ft. 100 | 1—4 | sq. ft. | 125·00 |
| 10 | Light doors on inside. | sq. ft. 42 | 0–12 | ,, | 31·50 |
| 11 | Flag stone slabs one inch thick set in mortar for window sills. | sq. ft. 74 | 10—0 | 100 sq. ft. | 7·40 |
| 12 | Teakwood windows iron barred and fully glazed complete with iron fixtures. | sq. ft. 93 | 1–12 | sq. ft. | 162·75 |
| 13 | Cupboards with light shutters | sq. ft. 56 | 1—0 | ,, | 56·00 |
| 14 | R. C. C. lintels over doors windows and cupboards. | cft. 49 | 1—0 | cft. | 49·00 |
| | Total Carried Forward ... | | | | 797·43 |

| Item No. | Name of Item. | Quantity | rate Rs. A. | per unit | amount. Rs. |
|---|---|---|---|---|---|
| — | Total Broght Forward ... | | | | 797·43 |
| 15 | Cut teak or sal wood work including fixing. | cft. 10·8 | 4—0 | cft. | 42·0 |
| 16 | Expanded metal trellis work in verandahs. | sq. ft. 408 | 25—0 | sq. ft. 100 | 102·00 |
| 17 | Cement plaster to walls. | sq. ft. 104 | 10—0 | | 10·40 |
| 18 | Gauze Wire netting 1½ ft. wide one inch mesh fixed as skirting to walls by iron staples for rat proofing. | Rft. 193 | 6—0 | Rft. 100 | 11·58 |
| 19 | White washing three coats. | sq. ft. 2432 | 0-12 | sft. 100 | 18·24 |
| 20 | Round teak wall plates 3 inch diameter. | Rft. 243 | 0—3 | Rft. | 45·56 |
| 21 | Corrugated iron sheet roofing complete with purlins, ridge, eaves boards etc. | sq. ft. 1920 | 24—0 | sq. ft. 100 | 460·80 |
| 22 | Sinks in bath room and kitchen complete with nhani traps pipes etc. | 2 Nos. | 5—0 | each | 10·00 |
| 23 | Sets of pegs. | 5 Nos. | 1—0 | ,, | 5-00 |
| 24 | Oiling wood work; painting iron work. | Lump | 1—0 | ,, | 15·00 |
| 25 | Loft in Kitchen. | do | 1—0 | ,, | 15·00 |
| 26 | Dhandies of bamboos for drying clothes, cradle hook, swing hooks etc. | do | 1—0 | ,, | 5·00 |
| | Total ... | | | | 1540 |
| | Say Rs. ... | | | | 1550 |

## Measurement Schedule.

| No. | Description of item. | No. | Length | Breadth | Depth or height | Quantity | Total Quantity. |
|---|---|---|---|---|---|---|---|
| 1 | Excavation for foundations in average soil. | | | | | | |
| | Side walls on the left and right. | 2 | 34–0 | 2–6 | 3–0 | 510·00 | |
| | Cross walls. | 4 | 27–0 | 2–6 | 3–0 | 810·00 | |
| | Partition walls in verandah | 2 | 6–6 | 2–6 | 3–0 | 97·50 | |
| | do central. | 1 | 11–0 | 2–6 | 3–0 | 82·50 | |
| | Side walls of bathroom | 2 | 6–6 | 2–6 | 3–0 | 97·50 | |
| | Rear do do do | 1 | 6–0 | 2–6 | 3–0 | 45·00 | |
| | Steps front and rear | 2 | 4–0 | 3–0 | 1–0 | 24·00 | |
| | Total ... | | | | | 1666·5 | cft. 1667 |
| 2 | Filling foundations with boulders and rubble in mud 3/4 of the above | $\frac{3}{4}$ | of | the | above | 1250 | |
| | Total ... | | | | | 1250 | cft. 1250 |
| 3 | Rubble stone in mud masonry for plinth inclnding cement pointing on the exposed surface above ground. | | | | | | |
| | Side wall on the left | 1 | 33–6 | 2–0 | 3–3 | 217·75 | |
| | do do on right middle portion | 1 | 15–0 | 2–0 | 3–3 | 47–50 | |
| | do front and rear portions | 2 | 9–0 | 2–0 | 3–0 | 108·00 | |
| | Cross wall middle | 2 | 27–6 | 2–0 | 3–3 | 357·50 | |
| | do rear of kitchen | 1 | 19–6 | 2–0 | 3–3 | 126·75 | |
| | do do of verandah | 1 | 8–0 | 2–0 | 3–0 | 48 00 | |
| | do in front of study | 1 | 10–9 | 2–0 | 3–3 | 70·25 | |
| | do do of verandah | 1 | 16–9 | 2–0 | 3–0 | 100·50 | |
| | Partition walls in verandahs | 2 | 7–0 | 2–0 | 3–3 | 21·00 | |
| | do do central | 1 | 11–6 | 2–0 | 2–9 | 74·75 | |
| | Side walls of bath room | 2 | 6–6 | 2–0 | 2–9 | 71·50 | |
| | Rear do do do | 1 | 6–6 | 2–0 | 2–9 | 35–75 | |
| | Steps | 2 | 3–6 | 3–0 | 0–9 | 15·75 | |
| | do | 2 | 3–6 | 2–0 | 0–6 | 7·00 | |
| | do | 2 | 3–6 | 1–0 | 0–6 | 3·50 | |
| | Total plinth masonry | | | | | 1375·50 | cft. 1375 |

Measurement Schedule—Contd.

| No. | Description of item. | No. | Length | Breadth | Depth or height | Quantity | Total Quantity |
|---|---|---|---|---|---|---|---|
| 4 | Damp proof course of 3/4 inch cement and sand with coal tar on top. | | | | | | |
| | Side walls | 2 | 33-0 | 1-6 | | 99·0 | |
| | Cross walls | 4 | 28-0 | 1-6 | | 168·0 | |
| | Partitions in verandahs | 2 | 7-0 | 1-6 | | 22 5 | |
| | do central | 2 | 12-0 | 1-6 | | 18·0 | |
| | Side walls of bath room | 2 | 6-6 | 1-6 | | 19·5 | |
| | Rear do do | 1 | 7-0 | 1-6 | | 10·5 | sq. ft. |
| | Total damp proof course | | | | | 3375 | 338 |
| 5 | Filling earth in plinth | | | | | | |
| | Front verandah | 1 | 17-6 | 6-9 | 2-6 | 295·00 | |
| | Study room | 1 | 8-9 | 7-9 | 2-6 | 170·00 | |
| | Bed room | 1 | 13-3 | 11-9 | 2-6 | 390·00 | |
| | Sitting room | 1 | 13-3 | 11-9 | 2-6 | 390·00 | |
| | Kitchen | 1 | 17-9 | 7-9 | 2-6 | 342·00 | |
| | Rear verandah | 1 | 8-6 | 6-9 | 2-6 | 197·00 | |
| | Bath room | 1 | 6-9 | 4-6 | 1-6 | 47·00 | cft. |
| | Total earth filling | | | | | 1831 | 1831 |
| 6 | Superstructure of pise earth-work. | | | | | | |
| | Side walls of study and kitchen | 4 | 9-0 | 1-6 | $\frac{8\cdot25+12\cdot75}{2}$ | 567·00 | |
| | do of bed and sitting R. | 2 | 15-0 | 1-6 | 13-1½ | 585·00 | |
| | Middle partition | 1 | 15-0 | 1-0 | 13-1½ | 262·00 | |
| | Middle cross walls | 2 | 28-0 | 1-6 | 13-1½ | 1003·00 | |
| | Side walls of bath | 2 | 6-6 | 1-6 | $\frac{8\cdot75+7\cdot25}{2}$ | 156·00 | |
| | Rear wall of do | 1 | 7-0 | 1-6 | 7·5 | 79·00 | |
| | Triangular portions | 2 | 15-0 | 1-6 | $\frac{0+6\cdot37}{2}$ | 40·00 | |
| | | 1 | 15-0 | 1-9 | $\frac{0+6\cdot37}{2}$ | 47·00 | |
| | Total superstructure ... | | | | | 2959 | |

Measurement Schedule—Contd.

| No. | Description of item. | No. | Length | Breadth | Depth or height | Quantity | Total Quantity |
|---|---|---|---|---|---|---|---|
| | Deduct. | | | | | | |
| | (a) Doors | 2 | 3-0 | 1-6 | 6-6 | 58·50 | |
| | do | 4 | 2-6 | 1-6 | 6-0 | 90·00 | |
| | do | 1 | 2-0 | 1-6 | 6-0 | 18·00 | |
| | (b) Windows in study, Kit- | 5 | 2-0 | 1-6 | 3-0 | 45·00 | |
| | chen and in sitting room | 2 | 5-0 | 1-6 | 6-0 | 90·00 | |
| | in Bed and Sitting Room | 1 | 2-6 | 1-6 | 1-0 | 3·75 | |
| | in bath room | 2 | 5-0 | 1-6 | 0-6 | 7·50 | |
| | (c) Lintels over doors | 3 | 4-6 | 1-6 | 0-4 | 6·75 | |
| | do do | 1 | 2-6 | 1-0 | 0-4 | 0·83 | |
| | do do | 1 | 4-0 | 1-6 | 0-4 | 2·00 | |
| | do do windows | 5 | 4-0 | 1-6 | 0-4 | 10·00 | |
| | do | 2 | 7-0 | 1-6 | 0-6 | 10·50 | |
| | do | 1 | 4-6 | 1-6 | 0-4 | 2·25 | |
| | do cupboards | 5 | 4-6 | 1-0 | 0-4 | 7·50 | |
| | Total deduction ... | | | | | 352·58 | |
| | Total Superstructure ... | | | | | 2959 | |
| | less deductions ... | | | | | 353 | |
| | | | | | | | cft. |
| | Net Superstructure ... | | | | | 2606 | 2606 |
| 7 | Flooring of broken brick bats and lime concrete | | | | | | |
| | Study room | 1 | 9-0 | 8-0 | | 72·0 | |
| | Bed and Sitting Rooms | 2 | 13-6 | 12-0 | | 324·0 | |
| | Kitchen | 1 | 18-0 | 8-0 | | 144·0 | |
| | Front verandah | 1 | 18-0 | 7-6 | | 135·0 | |
| | Rear do | 1 | 10-0 | 7-6 | | 75·0 | sq. ft. |
| | Total concrete flooring | | | | | 750 | 750 |
| 8 | Flag stone paving on lime concrete including cement pointing. | | | | | | |
| | For coping of front verandah | 1 | 18-0 | 1-9 | | 31·50 | |
| | do | 1 | 7-0 | 1-9 | | 12·20 | |
| | do rear do | 1 | 10-0 | 1-9 | | 17·50 | |
| | do | 1 | 7-0 | 1-9 | | 12·20 | |
| | Bath room | 1 | 7-0 | 5-0 | | 35·00 | sq. fts. |
| | Total flag stone paving | | | | | 108·4 | 108 |

Measurement Schedule—Contd.

| No. | Description of item. | No. | Length | Breadth | Depth or height | Quantity | Total Quantity |
|---|---|---|---|---|---|---|---|
| 9 | Doors teak or Sal wood plain planked with shutters complete with irons fixtures. | | | | | | |
| | Front verandah | 1 | 4–0 | | 7–0 | 28·0 | |
| | Rear do | 1 | 3–0 | | 6–6 | 21·5 | |
| | inner doors | 3 | 3–0 | | 6–0 | 36·0 | |
| | do | 1 | 2–6 | | 6–0 | 15·0 | sq. fts. |
| | Total doors ... | | | | | 100 | 100 |
| 10 | Doors with light frames and shutters. | 2 | 2–6 | | 6–0 | 30·0 | |
| | | 1 | 2–0 | | 6–0 | 12·0 | sq. ft. |
| | Total light doors ... | | | | | 42·0 | 42 |
| 11 | Flag stone slabs one inch thick set in lime mortar for window sills | 5 | 2–6 | 2–0 | | 25·3 | |
| | | 2 | 5–6 | 2–0 | | 22·0 | |
| | | 1 | 3–0 | 2–0 | | 6·0 | |
| | on top of steps | 6 | 3–6 | 1–0 | | 21·0 | sq. ft. |
| | Total ... | | | | | 74 | 74 |
| 12 | Windows iron barred and fully glazed as per (b) under deductions from item 6 above | | | | | | |
| | Total ... | | | | | 93 | sq. ft. 93 |
| 13 | Cupboards with light shutter | 5 | 2–6 | | 4–6 | 56 | ft. 59 |
| | Total cupboards ... | | | | | | sq.ft 56 |
| 14 | R. C. C. lintels over doors and windows as per (c) under deductions in item (6) above | | | | | 48·7 | |
| | Total R. C. C. lintels ... | | | | | 48·7 | cft. 49 |

4606?



Measurement Schedule—Conted.

| No. | Description of item. | No. | Length | Breadth | Depth or height | Quantity | Total Quantity |
|---|---|---|---|---|---|---|---|
| 15 | Cut teak or Sal wood work including fixing verandah posts | 5 | 0–4 | 0–4 | 9–0 | 5·0 | |
| | | 3 | 3–4 | 0–4 | 9–0 | 3·0 | |
| | Post plates | 1 | 19–0 | –3 | 0–4½ | 2·8 | |
| | | 1 | 11–0 | | | | |
| | Total wood work ... | | | | | 10·8 | cft 10· |
| 16 | Expanded metal trellis work in front and rear verandah | 1 | 18–0 | | 8–0 | 144 | |
| | | 1 | 10–0 | | 8–0 | 80 | |
| | | 2 | 9 | | $\frac{8+12\cdot5}{2}$ | 184·5 | |
| | Total ... | | | | | 408 | sq. ft. 408 |
| 17 | Cement plaster to walls Bath room | 2 | 7–0 | 4–0 | | 56 | |
| | | 2 | 5–0 | 4–0 | | 40 | |
| | Sink in kitchen | 2 | 2–0 | 2–0 | | 8 | |
| | Total ... | | | | | 104 | sq. ft. 104 |
| 18 | Wire netting 1½ ft. wide one inch mesh to be tacked to wall by iron staples at bottom of walls for ratproofing and plastered over with mud. | 1 | 34 | | | 39 | |
| | | 2 | 5–1 | | | 102 | |
| | | 1 | 5–2 | | | 52 | |
| | Total wire netting ... | | | | | 193 | Rft. 193 |
| 19 | White washing inner surface of walls 3 coats including dressing and leeping surface previously | | | | | | |
| | Front verandah | 1 | 9–0 | | $\frac{8+12\cdot5}{2}$ | 92·5 | |

Measurement Schedule—Contd.

| No. | Description of item. | No. | Length | Breadth | Depth or height | Quantity | Total Quantity |
|---|---|---|---|---|---|---|---|
| | Study room | 2 | 7–6 | | $\frac{8+12{\cdot}5}{2}$ | 153·5 | |
| | | 1 | 9–0 | | 8·25 | 74·25 | |
| | | 1 | 9–0 | | 12·5 | 125·5 | |
| | Bed and Sitting rooms | 4 | 13–6 | | 13 6 | 728·0 | |
| | | 2 | 12–0 | | 13·6 | 324·0 | |
| | Triangular portions | 2 | 12–0 | | $\frac{0+6{\cdot}5}{2}$ | 78·0 | |
| | Kitchen | 1 | 18–0 | | 8·25 | 148·5 | |
| | | 1 | 18–0 | | 12·5 | 225·0 | |
| | Rear verandah | 2 | 8–0 | | $\frac{8+12{\cdot}5}{2}$ | 164·0 | |
| | | 1 | 8–0 | | $\frac{8+12{\cdot}5}{2}$ | 82·0 | |
| | Bath room | 1 | 10–6 | | 12·5 | 131·0 | |
| | | 2 | 5–0 | | $\frac{7+9\ 5}{2}$ | 82·5 | |
| | | 1 | 7–0 | | 7·0 | 49·0 | |
| | | 1 | 7–0 | | 9·5 | 66·5 | |
| | Total white washing ... | | | | | 2431·7 | sq. ft. 2432 |
| 20 | Wall plates of round teak rafters 3 in. diameter | | | | | | |
| | Side walls of study and kitchen | 4 | 11–0 | | | 44·0 | |
| | Front of study room | 1 | 11–0 | | | 11·0 | |
| | Front and rear walls of bed and sitting room | 2 | 30–0 | | | 60·0 | |
| | Side walls of bed and Sitting Room | 6 | 14–6 | | | 87·0 | |
| | Rear wall of Kitchen | 1 | 20–0 | | | 20·0 | |
| | Side walls of bath room | 2 | 6–0 | | | 12·0 | |
| | Rear do do | 1 | 9–0 | | | 9·0 | |
| | Total wall plates ... | | | | | 243·0 | Rft. 243 |

Measurement Schedule—Contd.

| No. | Description of item. | No. | Length | Breadth | Depth or height | Quantity | Total Quantity |
|---|---|---|---|---|---|---|---|
| 21 | Corrugated galvanised iron sheet roofing complete with purlins, ridge, eaves boards etc. | | | | | | |
| | Front and rear wings | 2 | 34–0 | 27–0 | | 1836 | |
| | Bath projection | 1 | 14–0 | 6–0 | | 84 | sq. ft. |
| | Total roofing ... | | | | | 1920 | 1920 |
| 22 | Sinks in bath and kitchen complete with nhani traps pipes etc. | 2 | | | | 2 | Nos 2 |
| 23 | Sets of pegs | 5 | | | | 5 | No 5 |
| 24 | Oiling woodwork and painting iron work | —Lump— | | | | —Lump— | No 1 |
| 25 | Lofts in kitchen | | | | | | Nos 1 |
| 26 | Dhandies of bamboos for drying clothes below ceiling and cradle hook swing hooks etc. | | | | | | Lump. |

## IMPORTANT SPECIFICATIONS

Item No. 1. Excavation for foundation :—

The widths given are at the bottom of trenches. The excavated material to be stacked not nearer than 3 ft. from the edges of trenches. The excavation to be taken down to hard, incompressible, and stable material.

Item Nos. 2 and 3. Uncoursed rubble masonry in foundation and plinth :—

Please see pages 61 and 62 in respect of headers, bedding of stones, and precautions against hollows in the wall etc.

Item No. 4. Damp-proof course :—

This is to consist of a $\frac{3}{4}$ in. layer of concrete of gravel, sand and cement with a layer of coal tar on it, laid on

the top of the plinth masonry in the centre of the wall. (vide page 49)

Item No. 7. Concrete flooring :—

The space below the plinth to be filled with any earth except the black cotton soil (Regur) and should be thoroughly rammed and watered. On the top of this is to be laid, a 3 in. layer of concrete consisting of stone pebbles from river bed below 1½ in. size 4 parts, unscreened sand free from earth 2 parts, and lime mortar 1 part. If metal or pebbles are not available broken brick bats should be used. This layer to be rammed hard and while yet green a ½ in. layer of mortar prepared of 32 part of sand, 8 parts of lime mortar, and one of cement should be applied on top and moderately polished as the mortar sets This is to be kept moist by spreading wet grass, frequently watered for 15 days.

Item Nos. 9, 10 and 12. Doors and windows of teak or sal-wood :—

The frames to be made of R. C. C. as described in appendix No. 3

Light Doors :—The frames to be of R. C. C. as above. The shutters to be of a frame of teak wood ¾ in. thick with panels of waterproof canvas stretched and screwed on to it by means of wooden fillets.

The shelves to be of whole piece flag stones such as Shahabad, Tandur, Yerraguntla, Katni, Rewari etc. with the front edge rounded.

Item No. 18. Wire netting for 18 in. skirting :—

The lower end to be embedded into concrete floor at least 2 in. and only when the concrete has set, should the upper end be stretched well and the netting fixed on the surface of the wall by means of U-shaped staples 1½ in. long driven into the wall. The surface to be plastered over with mud again and leeped over with cowdung.

## PLAN NO. 3.

**Plinth area 1326 sq. ft.]** **[Cost Rs. 2290**

This snug little cottage, on account of the broad, low sweeping lines in the elevation gives an appearance of roominess. The deep verandah in front is most inviting. It gives a feeling of a little out-of-doors, and yet the dwarf wall on its edge affords a touch of privacy. The drawing room centrally situated will give the necessary warmth in winter and coolness in summer. The bed rooms are commodious and are pro-

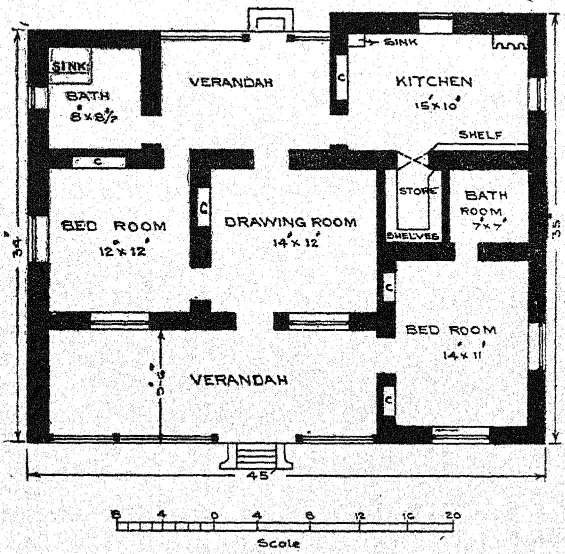
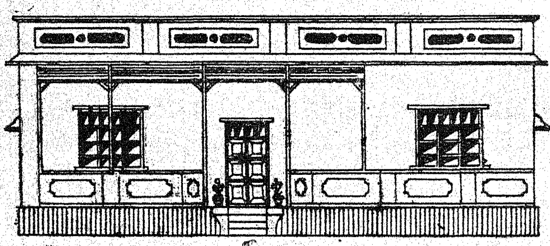



Fig. 61.

vided with separate bath rooms—a modern necessity. The kitchen is not only sufficiently spacious but the provision of a separate store room with rows of shelves adds to its convenience. The wide verandah enclosed by trellis on the rear side would provide an excellent dining room. The bath room is very conveniently situated.

This bungalow should be built on a slight elevation and should be in a setting of a garden in front, which would then command a view from the verandah and the front bed room. An ample provision of cupboards has been made in every room.



FRONT ELEVATION

Fig. 62.

## PLAN NO. 4.

**Plinth area 1462 sq. ft.]** **[Cost Rs. 2545**

This charming little cottage which is designed on the principles of the Indian architecture possesses all the advantages of the latter, without sharing a single disadvantage.

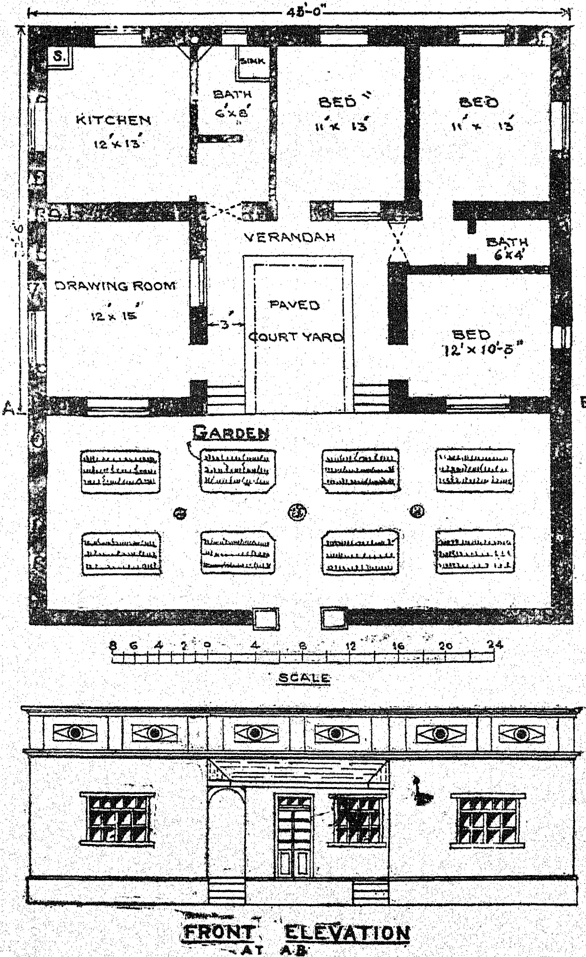



Fig. 63 & 64.

The open space in front is enclosed by a high compound wall and is entered through a massive wide gate. (not shown in elevation) There is, again, an

open paved court yard in the centre, round which runs a corridor to give an independent access to every room of the house. Light and breeze pervade the entire house and with them health and cheerfulness must predominently rule, because, there is not a single room even including the kitchen which is not open at least on two sides, still the house possesses the best privacy from the highways and byways. Imagine the front garden to be bristling with roses and an exhuberant vine trailing on the arch in front of the open paved court yard and you have to picture to yourself how the cottage would look in this best setting.

The interior arrangements fully synchronise with these exteriors. The sizes of all the rooms are very good for a small cottage like this. There are two bath rooms, each of which is independently accessible from any room. The drawing room and the bed room opposite it enjoy light and breeze on three sides. In spite of this all, the cost is only Rs. 2545; the garden and compound wall would cost extra.

## PLAN NO. 5

**Plinth area 1766 sq. ft.]** **[Cost Rs. 3250**

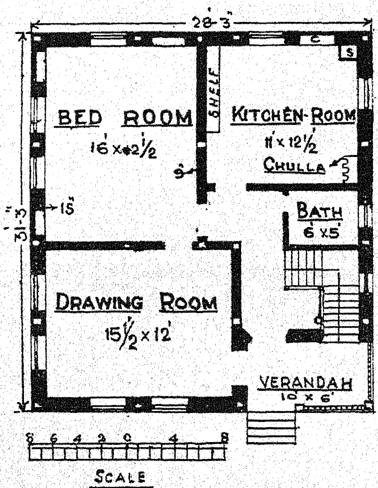
To one of limited means, who has spent years of his life in cities in the course of service, etc. in palatial buildings, but who now wants to lead a life in retirement with his large family

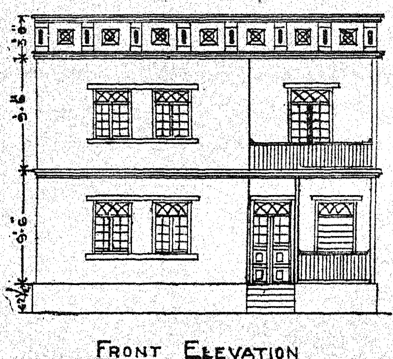
in a town on the country side, this design will make a strong appeal. Because, it combines economy with refinements of arrangements and comforts, almost amounting to luxuries. It illustrates the principle that simplicity and straightforwardness of design make not only for economy but also for comfort and health.

It is a storeyed building with a flat roof on. But a pitched roof would give the elevation even a better effect of simplicity and homelike appearance as the plan is a straightforward rectangle.

Ascending the flight of steps one enters the verandah. If space permits it is worth-while projecting the verandah a little more so as to make it 8 ft. wide at a little extra cost. The good sized drawing room is provided with four large glass windows which command a view of the landscape on two sides. Behind it is a bed room with as many windows and two fixed ward-robes. It is of such a size as one living even in mansions should envy. The spacious kitchen on the right hand side possesses every modern convenience. If necessary a back door may be provided in it in the corner of the shelf. The bath room entered through a lobby is accessible independently from every room. The space below the staircase can be utilised for storing bicycles or a pram. There is a large sized loft

provided (shown in the cross section in fig. No. 68) above the bath room for depositing lumber or storing fuel.

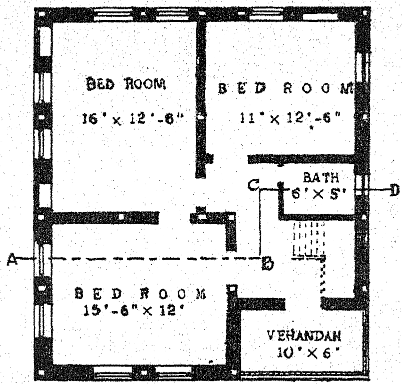


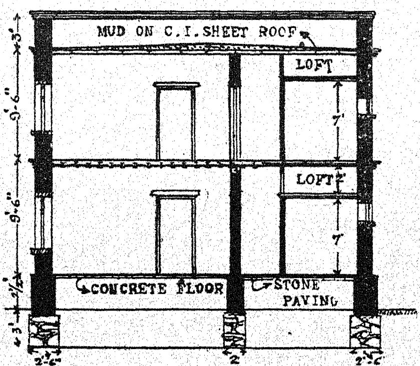

Figs. 65 & 66.

The entrance to the staircase is through the verandah and it lands one in the lobby on

the first floor. This may be optionally altered and the entrance may be made through the lobby on the ground floor with a landing in the




FIRST · FLOOR




SECTION ON ABCD

Figs. 67–68.

verandah upstairs. This would save a door on the ground floor.

On the first floor there are three bed rooms, a bath room, with a loft on its top, and a verandah. There is an independent passage to every bed room through the lobby, and the front verandah and the bath room are common and independently approachable from every bed room.

The roof, which consists of a 6 inch cover of mud on top of corrugated iron sheets, is bound to remain cool, absolutely leak-proof, and free from the danger of being blown away by a storm. Not only the stair case, but also the posts, floor, ceiling are all of fire-proof material. In fact, no wood is used in the building except for the shutters (not even for frames) of doors and windows. The upper floor and the roof are supported on a frame work of steel girders embedded in the walls, the white square dots shown in the walls on the plans denote their positions. All this make the building so strong that with the usual attention to the annual maintenance, the building can be guaranteed to last at least 150 years.

Still, the cost of the building does not exceed Rs. 3250 in Bombay and should be much less in Northern and Southern India. This has been made possible only by adopting some of the measures of economy suggested in the foregoing pages. A reference to the detailed estimate attached is invited for verification on this fact.

**Abstract of quantities and cost of house in Plan No. 5.**

| No. | Name of item. | Quantity. | rate. Rs. as. | per unit. | amount. |
|---|---|---|---|---|---|
| 1 | Excavation in average soil for foundations. | cft. 1295 | 0–12 | cft. 100 | 9·75 |
| 2 | Filling foundations with rubble and boulders in mud. | cft. 971 | 5—0 | ,, | 48·55 |
| 3 | Rubble in mud masonry for plinth including cement pointing on the exposed surface above ground. | cft. 1124 | 8—0 | ,, | 89·92 |
| 4 | Damp proof course. | sq. ft. 311 | 9—0 | sq. ft. 100 | 18·00 |
| 5 | Filling earth or murum upto plinth level. | cft. 1287 | 0—8 | | 6·44 |
| 6 | Cement concrete blocks below posts of rolled steel. | cft. 11 | 70—0 | cft. 100 | 7·70 |
| 7 | Steel frame-work to be embeded in walls. | cwts. 19· 5 | 9—0 | | 174·60 |
| 8 | Superstructure of burnt brick in lime on the exposed face and sun burnt bricks of same size in mud on the inner (Jibbi work). | cft. 948 | 15—0 | | 142·20 |
| 9 | Partition walls of sundried bricks in mud. | cft. 235 | 3—0 | | 7·05 |
| 10 | 4½ inch brick nogging in lime for partitions (Dhujji work). | sq. ft. 166 | 30—0 | | 49·8 |
| 11 | Doors of teak or salwood half glazed and half panelled and windows full glazed. | sq. ft. 209 | 1–12 | | 365·75 |
| 12 | Light doors on the inner side. | sq. ft. 51 | 0–12 | | 38·25 |
| 13 | Cupboards with wooden frame and light shutters. | sq. ft. 45 | 1—0 | | 45·0 |
| 14 | R. C. C. linlets over doors and windows. | 44 | 1—0 | | 44·0 |
| | Total carried forward ... | | | | 1047·01 |

Abstract of quantities and cost of plan No. 5.—Contd.

| No. | Name of item. | Quantity. | rate. Rs. as. | per unit. | amount. |
|---|---|---|---|---|---|
| | Total Brought forward ... | | | | 1047·01 |
| 15 | Flag stone paving on 3 inch lime concrete including cement pointing. | sq. ft. 162 | 20—0 | sq. ft. 100 | 32·40 |
| 16 | Indian patent stone floor. | 523 ,, | 15—0 | ,, | 78·45 |
| 17 | Cement plaster to walls. | 247 ,, | 10—0 | | 24·71 |
| 18 | Mud plaster to walls. | 1536 ,, | 3—0 | | 46·08 |
| 19 | Railing in Verandah | 12 Rft. | 1—0 | | 12·00 |
| 20 | Loft for lumber. | 1 No. | 10 | each | 10·00 |
| 21 | Sink complete in kitchen. | 1 No. | 6 | ,, | 6·00 |
| 22 | Nhani trap and pipe in bath room. | 1 No. | 2 | ,, | 2·00 |
| 23 | Shelf with brackets. | 1 No. | 4 | ,, | 4·00 |
| 24 | Sets of pegs. | 3 Nos. | 1 | ,, | 3·00 |
| 25 | Steps complete with brick work and stone paving on top. | Lump. 1 | | | 5·00 |
| 26 | Suspended flooring on walls. | sq. ft. 779 | 40 | sq. ft. 100 | 311·60 |
| 27 | White or buff washing 3 coats. | 1783 | 0—10 | ,, | 11·15 |
| 28 | Oiling wood work and painting iron work. | Lump. | | | 10·00 |
| 29 | Sunshades as per specifications. | 5 | 6 | each | 30·00 |
| | Total cost of the Ground-Floor. ... say | | | | 1633·40 **1633·00** |
| | FIRST FLOOR. | | | | |
| 30 | Fire proof stair case as per specifications. | 15 steps | 5—8 | per step | 82·50 |
| 31 | Rolled steel Frame-work of posts and beams. | cwts. 17 8 | 9—0 | cwt. | 160·50 |
| 32 | Superstructure of burnt brick masonry in lime on face and sundried bricks in mud on inner surface. | cft. 976 | 15 | cft. 100 | 146·25 |
| | Total carried forward ... | | | | 389·25 |

Abstract of quantities and cost of plan No. 5.—Contd.

| No. | Name of item. | Quantity. | rate. Rs. as. | per unit. | amount. |
|---|---|---|---|---|---|
| | Total Brought forward ... | | | | 389·25 |
| 33 | Partition walls of sundried bricks. | cft. 235 | 4—0 | cft. 100 | 9 40 |
| 34 | 4½ inch brick-nogging in lime (Dhujji work). | sq. ft. 166 | 30—0 | sq. ft. 100 | 49·80 |
| 35 | Doors half glazed and half panelled and windows fully glazed complete with fixtures. | sq. ft. 187 | 1—12 | ft. per sq. | 327·25 |
| 36 | Light doors on the inner side. | sq. ft. 51 | 0—12 | ft. per sq. | 38·25 |
| 37 | Cup-boards with light shutters. | sq. ft. 45 | 1—0 | ft. per sq. | 45·00 |
| 38 | R. C. C. lintels over doors windows and cupboards. | cft. 41 | 1—0 | cft. | 41·00 |
| 39 | Indian Patent stone floor (surfacing only) on lime concrete already laid. | sq. ft. 685 | 10—0 | sq. ft. 100 | 68·50 |
| 40 | Cement plaster to walls. | sq. ft. 247 | 10—0 | sq. ft. 100 | 24·70 |
| 41 | Mud plaster do | sq. ft. 1536 | 3—0 | sq. ft. 100 | 46·08 |
| 42 | Railing in verandah. | 16 Rft. | 1—0 | Rft. | 16·00 |
| 43 | Loft above bath room. | 1 No. | 10—0 | each | 10·00 |
| 44 | Nhani trap and pipe in bath room. | 1 No. | 2—0 | Lump. | 2·00 |
| 45 | Sets of pegs. | 4 Nos. | 1—0 | each | 4·00 |
| | | | | | 1071·23 |

Abstract of quantities and cost of plan No. 5.—Contd.

| No. | Name of item. | Quantity. | rate. Rs. as. | per unit. | amount. |
|---|---|---|---|---|---|
| | Total Brought forward ... | | | | 1071·23 |
| 46 | Roof of galvanised iron corrugated sheets on top of rolled steel joists with a covering of 6 inches of mud. | sq. ft. 883 | 40—0 | sq. ft. 100 | 353·20 |
| 47 | Brick in lime string course below and above parapet wall. | Rft. 238 | 0—3 | Rft. | 44·62 |
| 48 | Parapet wall of brick in lime masonry cement pointed on the inner side. | cft. 274 | 25—0 | cft. 100 | 68·50 |
| 49 | Lime plaster on the outer face of parapet wall. | sq. ft. 366 | 7—0 | sq. ft. 100 | 25·62 |
| 50 | Rain water spouts. | 6 Nos. | 2—0 | each | 12·00 |
| 51 | Sunshades for windows. | 5 Nos. | 6—0 | each | 30·00 |
| 52 | Oiling wood work and painting iron work. | Lump | | | 10·00 |
| 53 | Bamboo dhandies hung below ceiling in passages for drying clothes, cradle hook, swing hooks etc. | Lump | | | 5·00 |
| | | | | | 1620·17 |
| | Cost of ground floor. ... | 1633 | | | |
| | Cost of 1st floor. ... | 1620 | | | |
| | Total cost. ... | 3253 | | | |
| | say Rs. ... | **3255** | | | |

## *Measurement Schedule for Plan No. 5.*

| S. No. | Item. | No. | Length ft. in | Breadth ft. in | Depth ft. in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|
| 1 | Excavation in average soil for foundations. | | | | | | |
| | Long walls | 2 | 32  6″ | 2′  6″ | 3′ | 486·0 | |
| | Short walls | 2 | 24  6″ | 2′  6″ | 3′ | 367·5 | |
| | Wall on the rear of verandah | 1 | 10  0″ | 2′  6″ | 3′ | 75·0 | |
| | do do side of do | 1 | 3′  6 | 2′  6″ | 3′ | 26·2 | |
| | Partition wall between bed R. and Dr. R. | 1 | 16  3″ | 2′  0 | 3′ | 97·5 | |
| | Partition wall between bed R. and Kitchen | 1 | 14  9″ | 2′  0″ | 3′ | 8·85 | |
| | Partition wall between Dr. R. and Stair case | 1 | 5  6 | 2  0 | 3′ | 33·0 | |
| | Partition wall between Kitchen and Bath | 1 | 11  3 | 2  0 | 2′ | 45·0 | |
| | Partition wall round bath room | 1 | 10  0 | 2′  0 | 2′ | 40·0 | |
| | Below steps | 1 | 4  6 | 4  0 | 2 | 36·0 | |
| | Total excavation in average soil ... | | | | | 1295 | cft. 1295 |
| 2 | Filling foundations with rubble and boulders in mud. | | | | | | |
| | Three-fourth of excavation in (item 1). | 1 | 1295 | | $\frac{3}{4}$ | 971 | cft. 971 |
| | Total ... | | | | | | |
| 3 | Rubble stone in mud masonry for plinth including cement pointing on the exposed surface above ground level. | | | | | | |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item. | No. | Length ft. | in | Breadth ft. | in | Depth ft. | in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Long walls. | 2 | 32 | 0 | 2 | 0 | 3 | 3″ | 416 | |
| | Short walls. | 2 | 25 | 0 | 2 | 0 | 3 | 3 | 325 | |
| | Wall on the rear of verandah. | 1 | 10 | 0 | 2 | 0 | 3 | 3 | 65 | |
| | do do side of do | 1 | 5 | 3 | 2 | 0 | 3 | 3 | 34 | |
| | Partition wall between bed R. and Dr. R. | 1 | 16 | 3 | 1 | 6 | 3 | 3 | 79 | |
| | Partition wall between bed R. and Kitchen. | 1 | 15 | 3 | 1 | 6 | 3 | 3 | 74·33 | |
| | Partition wall between Dr. R. and Stairs. | 1 | 5 | 9 | 1 | 6 | 3 | 3 | 27·03 | |
| | Partition wall between Kitchen and bath. | 1 | 11 | 9 | 1 | 6 | 3 | 0 | 52·50 | |
| | Partition wall round bath. | 1 | 9 | 3 | 1 | 6 | 3 | 0 | 41·50 | |
| | Below steps. | 1 | 4 | 6 | 4 | 3 | 0 | 6 | 9·75 | |
| | | | | | | | | | 1124·1 | |
| | Total ... | | | | | | | | 1124 | cft. 1124 |
| 4 | Damp proof course of $\frac{3}{4}$ in. cement concrete and coal tar and sand above, through all the walls. | | | | | | | | | |
| | Long walls. | 2 | 32 | | 1 | 3 | | | 80·0 | |
| | Short walls. | 2 | 25 | | 1′ | 3 | | | 62·5 | |
| | Back wall of verandah | 1 | 10 | | 1′ | 3 | | | 12·5 | |
| | Side wall of do | 1 | 5 | 3 | 1′ | 3 | | | 6·5 | |
| | Wall between bed R. and Dr. R (central portion only.) | 1 | 16 | 3 | 0 | 9 | | | 12·0 | |
| | Wall between bed and Kitchen. | 1 | 15 | 3 | 0 | 9 | | | 12·0 | |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item. | No. | Length ft. | in | Breadth ft. | in | Depth ft. | in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Wall between Dr. R. and Stairs Partition only. | 1 | 5 | 9 | 0 | 9 | | | 4·5 | |
| | Wall between Kitchen and bath Partition only | 1 | 11 | 9 | 0 | 6 | | | 6·0 | |
| | Round bath. | 1 | 9 | 3 | 0 | 6 | | | 4·5 | |
| | Total ... | | | | | | | | 200·5 | sq. ft. 200 |
| 5 | Filling earth or murum inside walls upto plinth. | | | | | | | | | |
| | Bed room. | 1 | 15 | 3 | 11 | 9 | 2 | 6 | 450 | |
| | Kitchen | 1 | 10 | 3 | 11 | 9 | 2 | 6 | 300 | |
| | Drawing room | 1 | 14 | 3 | 11 | 3 | 2 | 6 | 240 | |
| | Bath and the space opposite it. | 1 | 4 | 3 | 11 | 9 | 2 | 6 | 125 | |
| | Stairs room. | 1 | 8 | 9 | 5 | 3 | 2 | 6 | 110 | |
| | Verandah. | 1 | 3 | 7½ | 6 | 7½ | 2 | 6 | 62 | |
| | Total filling ... | | | | | | | | 1287 | cft. 1287 |
| 6 | Cement concrete blocks below posts of rolled steel joists for frame work in 15 inch walls. | 22 | 1 | 6 | 1 | 0 | 0 | 4 | 11 | |
| | Total ... | | | | | | | | 11 | cft 11 |
| 7 | Rolled still joists with cement concrete filled inside their flanges erected as posts of frame work in 15 inch walls including jointing. | 14 | 9 | | 4″ × 1¾″ 5 lbs. | | per ft. | | 630 | |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item | No. | Length ft. in | Breadth ft. in | Depth ft. in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|
| | do in partition walls or without wall supports. | 8 | 9 | 4″ × 3″ or 9·5 lbs. per ft. | | 674 | |
| | Horizontal joints on top of vertical posts joined by pieces of angle iron complete with cement concrete between flanges, each 4″ × 1¾″ 5 lbs. per ft. | 2<br>3<br>1<br>1 | 30 6<br>27 6<br>18 0<br>12 0 | 173′ 6″ 5 lbs. per ft. | | 867 | 2171 lbs. or cwts. 19·4 |
| | Total steel work ... | | | | | 2171 | |
| 8 | Super structure of burnt brick in lime on the exposed face and sundried brick in mud on the inner face (jibbi work). | | | | | | |
| | Side wall on left. | 1 | 31 3 | 1 3 | 9 0 | 351·5 | |
| | do on right | 1 | 25 3 | 1 3 | 9 0 | 284·0 | |
| | Front wall of Dr. R. | 1 | 16 9 | 1 3 | 9′ 0 | 184·0 | |
| | Side wall of Verandah | 1 | 6 0 | 1 3 | 9′ 0 | 67·5 | |
| | Rear wall of do | 1 | 8 9 | 1 3 | 9′ 0 | 96·0 | |
| | do of Kitchen and bed. | 1 | 25 9 | 1 3 | 9 0 | 289·5 | |
| | Total ... | | | | | 1272·5 | |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item. | No. | Length ft. | in | Breadth ft. | in | Depth ft. | in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Deduct | 3 | 3 | 0 | 1 | 3 | 7 | 6 | 84·4 | |
| | (a) doors | 9 | 3 | 0 | 1 | 3 | 4 | 6 | 151·9 | |
| | (b) windows | 4 | 2 | 0 | 1 | 3 | 2 | 0 | 10·0 | |
| | (c) cupboards | 4 | 2 | 6 | 0 | 9 | 4 | 6 | 33·7 | |
| | (d) Lintels | | | | | | | | | |
| | over doors | 3 | 4 | 6 | 1 | 3 | 0 | 6 | 8·4 | |
| | over windows | 9 | 4 | 6 | 1 | 3 | 0 | 6 | 25·2 | |
| | | 2 | 3 | 6 | 1 | 3 | 0 | 6 | 4·4 | |
| | Cupboards | 4 | 4 | 0 | 0 | 9 | 0 | 6 | 6·0 | |
| | Total deduction ... | | | | | | | | 324·0 | |
| | Total Superstructure masonry. | | | | | | | | 1272 | |
| | Deduction | | | | | | | | 324 | |
| | Net Superstructure masonry. | | | | | | | | 948 | cft. 948 |
| 9 | Partition walls of Sundried bricks between Dr. R. and Bed R. | 1 | 15 | 6 | 0 | 9 | 9 | 0 | 105·7 | |
| | do Bed R. & Kitchen. | 1 | 16 | 0 | 0 | 9 | 9 | 0 | 108·0 | |
| | do Dr. R. and Stairs. | | 6 | 6 | 0 | 9 | 9 | 0 | 43·9 | |
| | Total ... | | | | | | | | 257·6 | |
| | Deduct for doors. | 2 | 2 | 6 | 0 | 9 | 6 | 0 | 22·5 | |
| | Net partition wall masonry. | | | | | | | | 235·1 | cft. 235 |
| 10 | $4\frac{1}{2}$ in brick nogging in lime for partitions (Dhujji work) between Kitchen and bath. | 1 | 12 | 6 | | | 9 | 0 | 112·5 | |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item. | No. | Length ft. in | | Breadth ft. in | Depth ft. in | | Quantity. | Total. |
|---|---|---|---|---|---|---|---|---|---|
| | Round bath room. | 1 | 11 | 6 | | 7 | 0 | 80·5 | |
| | Total Brick nogging. | | | | | | | 193·0 | |
| | Deduct doors. | 1 | 2 | 6 | | 6 | 0 | 15 | |
| | | 1 | 2 | 0 | | 6 | 0 | 12 | |
| | Total deduction ... | | | | | | | 27 | |
| | Net brick nogging. | | | | | | | 166 | sq. ft. 166 |
| 11 | Doors of teak or sal wood half glazed and half panelled. | | | | | | | | |
| | Front. | 3 | 3 | 0 | | 7 | 6 | 67·5 | |
| | Bath room. | 1 | 2 | 0 | | 6 | 0 | 12·0 | |
| | Windows iron barred and fully glazed complete with brass fixtures. | 9 | 3 | 0 | | 4 | 6 | 121·5 | |
| | | 2 | 2 | 0 | | 2 | 0 | 8·0 | |
| | Total doors and windows glazed. | | | | | | | 209 | sq. ft. 209 |
| 12 | Doors of light frames and light shutters complete with iron fixtures on the inner side. | 2 | 3 | 0 | | 6 | 0 | 36 | |
| | | 1 | 2 | 6 | | 6 | 0 | 15 | |
| | Total light doors ... | | | | | | | 51 | sq. ft. 51 |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item. | No. | Length ft. | in | Breadth ft. | in | Depth ft. | in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|
| 13 | Cupboards with wooden frames and light shutters complete. | 4 | 2 | 6 | | | 4 | 6 | 45 | |
| | Total cupboards ... | | | | | | | | 45 | Sq. ft. 45 |
| 14 | R. C. C. lintels over doors, windows and cupboards as shown under deductions in item 8 (d). | 1 | | | | | | | 44 | |
| | Total R. C. C. lintels. | | | | | | | | 44 | cft. 44 |
| 15 | Shahabad, Yerranguntla, Katni, or similar slab paving on 3 inch lime concrete including cement pointing. | | | | | | | | | |
| | Bath room. | 1 | 6 | 0 | 5 | 0 | | | 30 | |
| | Verandah. | 1 | 10 | 0 | 6 | 0 | | | 60 | |
| | | 1 | 7 | 0 | 6 | 6 | | | 45 | |
| | Passage. | 1 | 4 | 0 | 6 | 6 | | | 27 | |
| | Total paving ... | | | | | | | | 162 | Sq. ft. 162 |
| 16 | Indian patent stone floor on 4 inch lime concrete. | | | | | | | | | |
| | Drawing Room. | 1 | 15 | 6 | 12 | 0 | | | 186 | |
| | Bed do | 1 | 16 | 0 | 12 | 6 | | | 200 | |
| | Kitchen. | 1 | 11 | 0 | 12 | 6 | | | 137 | |
| | Total Indian patent stone flooring. | | | | | | | | 523 | Sq. ft. 523 |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item. | No. | Length ft. in | | Breadth ft. in | Depth ft. in | | Quantity. | Total. |
|---|---|---|---|---|---|---|---|---|---|
| 17 | One inch cement plaster to walls for one foot skirting all round at bottom for rat proofing. | | | | | | | | |
| | Drawing room all round. | 1 | 55 | | | 1 | 0 | 55 | |
| | Bed room all round. | 1 | 57 | 0 | | 1 | 0 | 57 | |
| | Kitchen. | 1 | 47 | 0 | | 1 | 0 | 47 | |
| | Bath (also for water proofing). | 1 | 22 | 0 | | 3 | 0 | 66 | |
| | Passage. | 1 | 15 | 0 | | 1 | 0 | 15 | |
| | Verandah. | 1 | 7 | 0 | | 1 | 0 | 7 | |
| | Total cement plaster. | | | | | | | 247 | Sq. ft. 247 |
| 18 | Mud plaster to walls on the inner side. | | | | | | | | |
| | Drawing Room all-round | 1 | 55 | 0 | | 8 | 0 | 440 | |
| | Bed room do | 1 | 57 | 0 | | 8 | 0 | 456 | |
| | Kitchen do | 1 | 47 | 0 | | 8 | 0 | 376 | |
| | Bath do | 1 | 22 | 0 | | 4 | 0 | 88 | |
| | Passage. | 1 | 15 | 0 | | 8 | 0 | 120 | |
| | Verandah. | 1 | 7 | 0 | | 8 | 0 | 56 | |
| | Total mud-plaster ... | | | | | | | 1536 | Sq. ft. 1536 |
| 19 | Railing in Verandah. | 1 | 12 | | | | | 12 | |
| | Total railing ... | | | | | | | 12 | R. ft. 12 |
| 20 | Loft above bath room 6 × 5 × 2' high. | No. 1 | | | | | | 1 | No. 1 |
| 21 | Sink, in Kitchen with paving, pipe, parapets and cement plaster on sides complete with nhani trap. | No. 1 | | | | | | 1 | No. 1 |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item. | No. | Length ft. in | Breadth ft. in | Depth ft. in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|
| 22 | Nhani trap and pipe in bath room. | No. 1 | | | | 1 | No. 1 |
| 23 | Shelf with brackets in Kitchen. | No. 1 | | | | 1 | No. 1 |
| 24 | Sets of pegs. | Nos. 3 | | | | 3 | No. 3 |
| 25 | Steps complete with brick bats set in lime, with $1\frac{1}{2}$ inch flag stone paving on top, of rounded edges projecting $\frac{1}{2}$ inch. | Lump | | | | | No. 1 |
| 26 | Suspended flooring of $4'' \times 1\frac{3}{4}''$ steel joists 5 lbs per foot length laid as detailed in the specifications. | 1 | 27 0 | 30 0 | | 810 | |
| | Total ... | | | | | 810 | |
| | Deduct for stair case well. | 1 | 3 0 | 7 6 | | 22·5 | |
| | | 1 | 3 0 | 3 0 | | 9 | |
| | Total deduction ... | | | | | 31.5 | |
| | Net suspended flooring. | | | | | 779 | Sq. ft. 779 |
| 27 | White or buff washing 3 coats on the plastered surface (items 17 & 18 together.) | | | | | 1783 | Sq. ft. 1783 |
| 28 | Oiling wood-work, painting iron-work. | Lump | | | | | No. 1 |
| 29 | Sunshades for windows. | Nos. 5 | | | | | No. 5 |

Measurement Schedules Plan No. 5.—Contd.

| S No. | Item | No. | Length ft. in | Breadth ft. in | Depth ft. in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|
| | FIRST-FLOOR. | | | | | | |
| 30 | Fire proof staircase complete as per specifications. | Steps 15 | | | | 15 | |
| | Total steps ... | | | | | | No. 15 |
| 31 | Rolled steel joists for frame work. Posts in 15 in. walls as on ground floor. | 14 | 4″ × 9 × | 1¾″ 5 lbs. per ft. | | 630 | |
| | Do. in partitions or without wall supports. | 6 | 4″ × 9 × | 3″ 9·5 lbs per ft. | | 505 | |
| | Horizontal joists 4″ × 1¾″ on top as on ground floor. | | | | | 867 | |
| | Total steel frame work ... | | | | | 2002 | lbs. 2002 or 17·8 cwts. |
| 32 | Superstructure of burnt bricks in lime on outer face and kacha bricks of same size in mud on the inner. The same as on ground floor. | | | | | 1272·5 | |
| | Deduction. The same as on the ground floor. Viz 324 cft. less 28 cft. for one door less in the rear wall of verandah. | | | | | | |
| | Total deduction ... | | | | | 296 | |
| | Net superstructure masonry. | | | | | 976 | 976 cft. |

Measurement Schedules Plan No. 5.—Contd.

| S. No. | Item. | No. | Length ft. in | Breadth ft. in | Depth ft. in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|
| 33 | Partition walls of sun-dried bricks. The same net quantity as on the ground floor. | | | | | | 235 cft. |
| 34 | $4\frac{1}{2}$ in brick nogging. Same as on ground floor. | | | | | | sq. ft. 166 |
| 35 | Doors half glazed and half panelled and windows fully glazed–one door less than on the G. F. 209–22. | | | | | 187 | sq. ft. 187 |
| 36 | Light doors on inner side complete with iron fixtures—same as on G. F. | | | | | 51 | 51 sq. ft. |
| 37 | Cupboards with wooden frames and light shutters—same as on the G. F. | | | | | 45 | 45 sq. ft. |
| 38 | Lintels of R. C. C. as on G. F. less for one door. | | | | | 41 | 41 cft. |
| 39 | Indian patent stone flooring—the same as for items 15+16 in the ground floor estimate. (162+523) | | | | | 685 | sq. ft. 685 |
| 40 | Cement plaster to walls same as on the G. F. | | | | | 247 | sq. ft. 247 |
| 41 | Mud plaster—same as on G. F. | | | | | 1536 | sq. ft. 1536 |
| 42 | Railing in Verandah. | 1 | 10 0 | | | 10 | |
| | | 1 | 6 0 | | | 6 | |
| | Total railing ... | | | | | 16 | 16 Rft. |
| 43 | Loft above bath room. | 1 | | | | 1 | No. 1 |

Measurement Schedule Plan No. 5.—Contd.

| S. No. | Item. | No | Length ft. in | Breadth ft. in | Depth ft. in | Quantity. | Total. |
|---|---|---|---|---|---|---|---|
| 44 | Nhani trap and pipe in bath-room. | 1 | | | | 1 | No. 1 |
| 45 | Sets of pegs. | 4 | | | | 4 | No. 4 |
| 46 | Roof of G. I. sheets 26 B. W. G. fixed flat on top of steel joists $4'' \times 1\frac{3}{4}'' \times 5$ lbs. laid 2 ft. apart with 6 inch covering of mud of white earth. | 1 | 31 3 | 28 3 | | 883 | |
| | Total roof ... | | | | | 883 | sq. ft. 883 |
| 47 | Brick in lime string course all round below and above parapet wall. | 2× 119 | | | | 238 | Rft. 238 |
| 48 | Parapet wall of burnt brick in lime cement pointed on inside. | 2 | 31 3 | 0 9 | 3 | 140·5 | |
| | | 2 | 29 9 | 0 9 | 3 | 133·5 | |
| | Total ... | | | | | 274 | 274 cft. |
| | | | | | | 274 | |
| 49 | Lime plaster on the outer face including cornices. | 2 | 31 3 | | 3 | 187·5 | |
| | | 2 | 29 9 | | 3 | 178·5 | |
| | Total ... | | | | | 366 | sq. ft. 366 |
| 50 | Rain water spouts. | No. 6 | | | | 6 | Nos. 6 |
| 51 | Sunshades for window. | No. 5 | | | | 5 | No. 5 |
| 52 | Oiling wood work and painting exposed steel work. | 1 | Lump | | | | No. 1 |
| 53 | Dhandies of bamboos for drying clothes, cradle hook, swing hooks etcs. | Lump | | | | Lump | No. 1 |
| | | | | | | Lump | No. 1 |

## IMPORTANT SPECIFICATIONS FOR PLAN NO. 5

Please refer to the specifications given for plan No. 2 with the following addition:—

Item No. 6:—Cement concrete blocks:—

These are to be cast in situ with concrete made of 5 parts of stone metal, $2\frac{1}{2}$ parts of sand, and 1 of cement. In places where stone metal and sand are not available at a cheap rate, metal of over burnt (vitrified) bricks may be used, or even whole vitrified bricks may be laid in cement mortar of 4 of sand and one of cement.

Item Nos. 7 and 31. Steel frame work:—

For posts which are to be embedded in walls and which, therefore, will get a lateral support on all sides, joists $4'' \times 1\frac{3}{4}''$ size weighing 5 lbs. per foot to be used. Elsewhere, i. e., in partition walls and at other places where they are to have small or no support, $4'' \times 3''$ joists weighing 9 lbs. per running ft. to be used. The flanges of both the sorts of joists to be filled with cement concrete of 6:3:1 proportions. Vertical posts to be joined to the horizontal joists on their tops by means of an angle iron piece on one side bolted to both where the posts are embedded in wall and by means of two pieces on both sides in places where the posts will have no lateral supports. If the posts are crooked or bent they are to be straightened and tested for plumbness before concrete is filled in.

Item No. 8. Superstructure of burnt brick in lime facing and unburnt brick in mud backing:—

The burnt bricks to be kept immersed in water for two hours before being used. The lime mortar to be spread in a width of two inches from the face and the joint finished off neatly, straight and uniform in width

and rubbed hard after 24 hours with a *nahila*. The face to be watered frequently for at least a week. The mud mortar to be used on the inside must be a little stiff.

Item No. 26. Suspended flooring:—This is to consist of $4'' \times 1\frac{3}{4}''$ steel joists weighing 5 lbs. per ft. laid from left to right in one piece each i. e. of 27 ft. length on top of the bed room and kitchen and bath as far as the partition wall and its continuation between the bed room and drawing room. In the remaining portion they are to be laid at right angles to those previously laid, i. e., from the central partition wall to the front wall, leaving an open space for the staircase well.

In the one ft. space between the two adjacent joists square flooring tiles $12'' \times 12'' \times 2''$ thick or any kind of flag stone slabs $1\frac{1}{2}''$ thick should be inserted from one end and the joints pointed with cement. The space above the slabs to be filled with either murum, brickbats or any other similar stuff not liable to decay, and rammed well. It is desirable to give two coats of coal tar or oil paint to the joists previously.

If either tiles or any sort of flag stone slabs are not available at cheap rate, pieces of waste timber planed on the lower side one ft. long may be inserted from one end. They must be one inch thick at the thinnest side.

Item No. 30. Fire-proof stair case:—

Please see pages 134 and 135.

Item No. 45. Roof of G. I. sheets on top of rolled steel joists with a 6 in. covering of mud:—

The joists to be laid at 2 ft. distance c. to c. and to be given the inclination according to the local practice (usually $\frac{1}{4}''$ per ft.) from the central ridge towards both right and left sides and the corrugated sheets to be simply

laid on them. They need not be fixed to the joists as the weight of the earth above them will hold them in position. Only a ridge capping is necessary. Two coats of coal tar to be applied to them and then earth in the form of stiff mud to be spread in a layer of 6 inches and rammed hard. When dry the surface to be leeped with sodiumised clay or at least white earth, cow-dung, and cement mixed in the porportions of 12 : 4 : 1 respectively.

## PLAN No. 6.

**Plinth Area 2724 sq. ft. ]** **[ Cost Rs. 7000**

This plan is rather on a pretentious scale. It is given here not so much as an example of economy but to illustrate the principle that well conceived simplicity and attention to details in the internal arrangements are the key-note of a good design which makes for the comforts of a real home.

The delightful semicircular front verandah enjoys a vista and breeze from three directions. On the left side there is a guest room with the modern necessary convenience of a bath room attached to it. The drawing room is located in the heart of the house and occupies the spacious square room. On the right hand side there is a large verandah 11 ft. wide including the space occupied by the stairway. This verandah may, if necessary, be partly enclosed and a small study room formed out of it. The

kitchen with ample cupboard space and two windows is compact and convenient and the additional feature of a smoke outlet in a corner adds much to its value. In front of the kitchen and behind the drawing room is placed the

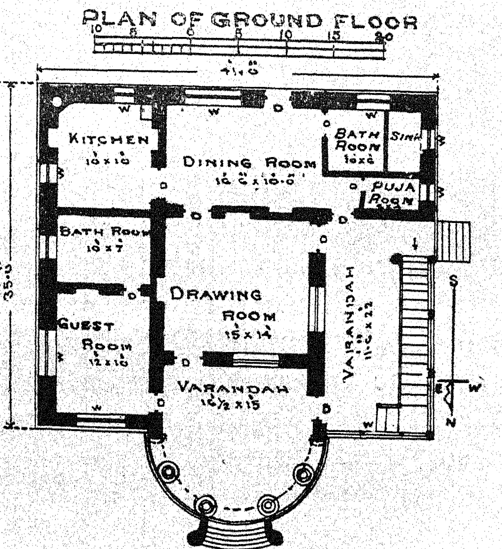



Fig. 69.

commodious dining room and the right hand corner is occupied by a bath room of convenient size. The small space between the bath room and the verandah is enclosed and formed into a small Puja or Prayer room. Removed away from the hubub of the rest of the house this small corner will not fail to give that pleasure and peace of mind which the religious

minded person longs to seek in solitude in this materialistic world.

For reaching the dining room the guest need not pass through the drawing room, but through the verandah on the left side and enter through the door near the Puja room. If a separate bath room is not required to be attached to the guest room it would be an

FRONT ELEVATION

Fig. 70.

excellent plan to turn it into a store room for the kitchen. All that is necessary for this is to close the door communicating with the guest room and open another in the wall between the kitchen and the store room.

The staircase is wide and easy to climb and all built of fire-proof material. Upstairs there are three bed rooms, the special feature of which is that each enjoys free breeze from three sides and that the small bath room

can be entered independently from every bed room through the lobby, and further that the verandah and open terrace also can be made use of by the occupiers of the bed rooms quite independently.

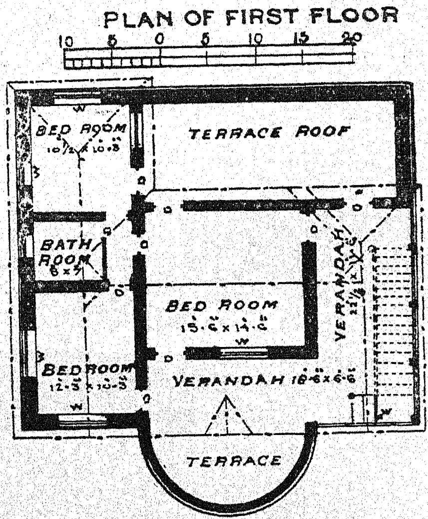



Fig. 71.

If a small bed or study room is built on the right hand side of the open terrace on the rear side it would be open on all four sides.

If the same arrangement of rooms as on the ground floor is made upstairs and the latter flat let as a separate tenement the independent entrance to the staircase on the left hand side would admit even of this.

And with all these conveniences and special features the cost in an up-country town

for a solid structure of stone or brick in lime walls, paving of Indian patent stone floor in the entire house, R. C. C. suspended flooring, R. C. C. round posts in the front verandah, fully glazed doors and windows, manglore tiled roof etc. the cost does not exceed Rs. 7000.

Thus this cottage rightly combines symmetry, simplicity, dignity, comfort and economy all in one. This is actually built at Nasik

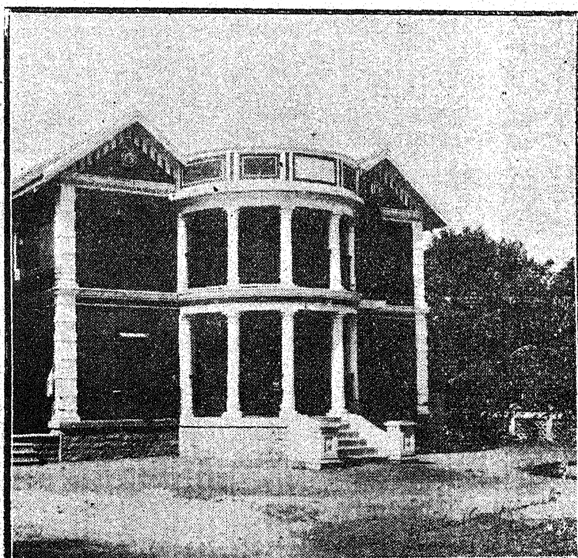


Fig. 72.

in the Bombay Presidency on the Bombay Agra Road, with a slight alteration in the roof. Fig. 72 shows a photographic view of the same.

## MORE PRACTICAL SUGGESTIONS AND HINTS FOR ECONOMY

(1) Cutting up timber by departmental agency should not be attempted by laymen, as it is a risky business. The purchase of logs requires experience. Then the sawing requires experience, care and constant supervision. The waste timber obtained can not be economically utilised on such a small building work in hand and thus forms a cumbersome heap which ultimately fetches no more than its fuel value. Besides, for want of getting scantlings of the proper size in time the progress of work is hindered.

(2) When the work is small, and particularly of the nature of repairs it is often cheaper and more convenient to use a mixture of 7 or even 8 parts of sand to 1 of cement instead of lime mortar.

(3) Even in places where excellent stone is available at a cheap rate cut stone steps prove to be a very costly item. Unless finely dressed they do not present a neat appearance and dressing costs a good deal. Instead of this if steps are roughly formed of lime concrete,

brick or rubble masonry in lime and flat flag stones with edges rounded in the front, are laid on their top they are not only cheaper but also look clean and equally well if not better.

(4) Verandahs and passages should, as far as possible, be paved with stone slabs, so also the door sills, if the floor is to be of murum or mud. These places are subject to considerable wear.

(5) The economical stock sizes of steel joists are 4″ by $1\frac{3}{4}$″ or $4\frac{3}{4}$″ by $1\frac{3}{4}$″ and if one dimension of rooms is kept 12 to 13 ft. great economy is caused by their use for upper flooring. Similarly the stock size of timber scantling is 6 ft. length. If the sizes of windows and cupboards are limited to that length considerable economy results.

(6) Except perhaps in the exposed situations, wood should not be painted, as the paint has to be renewed at frequent intervals at great cost and if it is not done in time the appearance looks shabby. Instead of this if it is coated with some cheap mixture such as solingnum or ceaserot or simple linseed oil and coal tar boiled together and mixed in kerosene oil, to form a paint of dark colour its appearance can be preserved for a long period very cheaply by occasionally wiping the surface with a rag dipped into kerosene oil.

(7) Painting and varnishing done in wet weather is useless. It should always be done in the hot weather.

(8) Lead paints are cheaper and better for iron work. Zinc paints are not spoiled by the action of smoke. At the most washing the surface with a solution of washing soda gives it the appearance of freshness.

# APPENDIX No. 1

## A Note on clays impervious to water

There are four main types of soil which occupy the major part of India. They are:—(1) Alluvium, which covers an extensive area of the Indo-Gangetic plain in Northern India, and in Sind. (2) Black cotton soil or "Regur". (3) The black or red soils overlying the metamorphic rocks of Madras, and (4) The laterite soils which occupy the coastal parts of the Sahyadri and occur also at many places in Southern and Central India and the United Provinces.

Between these there are innumerable minor varieties caused by local conditions. Thus, though alluvium is yellow loam, in many parts it is sandy or even clayey, the latter is generally pink and sometimes even bluish green in colour. The stickiness of the clayey soils is due to the high percentage of alumina and iron they contain, and the impermeability of the soils is due to the alkali bases present in them, especially in the form of sodium.

Generally speaking all the varieties are alkaline in reaction. Exceptions to these may be found in certain small areas, where the rainfall is high and wind fierce. For instance, in Assam and in the Konkan of the Deccan the soil is distinctly acidic in character. The alkalinity is due to the presence of a strong alkali base, and comparatively a weak radical. The acid soils contain a high proportion of hydrogen ions, and the alkaline soils, that

of hydroxyl ions. The bases in soils are either calcium, magnesium, potassium, or sodium. Of these calcium and magnesium bases tend to make the soil loose, and those of potassium and sodium, especially the latter, impervious.

The object in making the earth suitable for building purposes is just the opposite of what it is in making it fit for agriculture. For the latter we try to reduce alkalinity by mixing certain acid materials, whereas, for building purposes our aim is to render a neutral soil, alkaline by adding certain suitable soils to it. Both these are rendered possible on account of a certain chemical affinity which exists between a soil and a salt solution.

*When soils are brought in contact with solutions of salts, a chemical reaction takes place and the bases are mutually exchanged.*

This phenomenon is called the **Exchange of Bases.**

Thus it is possible to reduce a soil containing a preponderence of a certain base to another of any other base. For agricultural purposes, soils containing potassium or sodium bases, which make them stiff, are sought to be reduced to those of calcium base, as the latter makes them more or less loose and porous. On the other hand the object to be aimed at, when rendering earth suitable for building purposes, is to displace other bases in a soil by sodium base, so as to make it impervious to water, or to "Sodiumise" it, to speak in technical terms.

It is evident that it is comparatively easy to sodiumise a soil which is agriculturally poor, for, it already contains some sodium salts. In order to understand the exact chemical action involved, suppose we have got handy and in abundance a soil containing calcium as the base. When we treat a sample of this soil with solution

of common salt ( which contains sodium ), what happens is this :—

$$Ca\ Clay + 2Na_2\ Cl \leftrightarrows Ca\ Cl_2 + 2Na\ Clay^{*} \ldots\ldots (1)$$

We get calcium chloride and sodium clay. Instead of treating the soil with solution of common salt ( sodium chloride ), suppose we do so with sodium sulphate ( $Na_2 SO_4$ ) still the same result is obtained as far as sodium and calcium clays are concerned :—

$$Ca\ Clay + Na_2\ SO_4 \rightleftarrows Ca\ SO_4 + 2\ Na\ Clay^{*} \ldots\ldots (2)$$

Sodium clay is produced again. That is, the original calcium base of the soil is turned into sodium base.

Now, sodium clay in presence of water, hydrolyses, producing hydroxyl ions of sodium ( Na OH ) which cause alkalinity. The chemical equation for this is this :—

$$Na\ Clay + H_2O = Na\ OH + H\ Clay \ldots\ldots\ldots (3)$$

Even a trace of NaOH tends to render the soil impervious to water. The sodium clay formed has its particles highly dispersesd ; they remain for a long time in suspension in water, and thus make the soil sticky and impervious. This is entirely due to the high electro-kinetic potential of NaClay which is $1\frac{1}{2}$ times that for the calcium clay

The free sodium hydroxide ( NaOH ) renders the soil impervious to water and under suitable circumstances it further reacts on the aluminium hydroxide if present and forms sodium aluminate. When this happens the aluminium hydroxide precipitates in a gelatenous condition and further helps to make the soil impervious to water.

---

* This is not strictly correct. The valancy of clay is not definitely fixed. Besides, this is not a definite chemical change but a physico-chemical one.

Thus when salts of sodium are mixed with any soil and water is added to it, in course of time NaOH (sodium hydroxide) is formed which is responsible for causing the imperviousness.

The soil in, and in the neighbourhood of, village sites contains a lot of sodium salts, but it also contains potassium salts in the form of nitre ( $KNO_3$ ), as a result of accumulation on it, of nitrogenous matter, such as urine, excreta etc. for a number of years. In fact this nitre lends the white colour to it. When this 'white earth' comes in contact with rain water, for instance, on the top of mud roofs, the potassium salts, are leached out especially from the surface, and the latter soon automatically becomes impervious and prevents penetration of water. The same thing happens, when water is mixed with such white earth, that is, most of the potassium salts are leached out and the sodium salts which remain in preponderence, impart impermeability to it.

One often sees that this white earth or "Khari Mitti" used for roofing or other purposes deteriorates in course of time. The reason is, that rain water, particularly in the beginning of monsoon, is charged with carbon-dioxide from the atmosphere dissolved in it. When white earth in positions like that on the top of mud roofs, is long exposed to such rain, the $CO_2$ dissolved in the rain-water, forms with the Na-salts in the earth, sodium-bicarbonate ( $NaHCO_3$ )

$$H_2O + CO_2 = H_2CO_3 \quad \ldots\ldots\ldots\ldots(4)$$

$$\text{Na Clay} + H_2CO_3 = \text{H Clay} + NaHCO_3 \ldots\ldots(5)$$

When this takes place Na is easily removed from the soil in the form of bicarbonate of soda, and the alkalinity and with it the imperviousness begin to disappear, because

the process of hydrolysis is suppressed and free alkali is no more produced. In such circumstances in order to render the roofing earth again impervious, the remedy is to mix fresh sodium salts with it and leach them out. It has been observed after experiments that when the concentration of Na salts is 0'5 p.c., optimum impermeability to water is obtained. Further concentration than this tends to prevent hydrolysis of NaClay and reduce its impermeability.

## APPENDIX No. 2

### Duties of a House-Holder for Preventing or Fighting an Epidemic.

If in the centres called "HOME" the fonndations of health are laid, the task of Government and Local Bodies would at once be simplified. "If the houses are taken care of", says the sanitarian, "the towns will take care of themselves". If this were to take place there would be no necessity of legislative acts in respect of sanitation to be enforced. But unfortunately in India, the ignorance even of the fundamental principles of hygiene, coupled with prejudices, peculiar religious and social customs, and domestic habits, so ingrained in the course of ages, as to become innate and form an integral part of the life of the individual and the community to which he belongs, come in the way and cause him to offer a passive resistance to any sanitary measure. What is required is the establishment of sanitary associations in every village and town to make co-ordinated strenuous efforts, (in co-operation with the Local Bodies) by every possible means to impress on the people the necessity of observing sanitary precautions with the ultimate object of gradually creating a desire on their part for healthier surroundings. The sense of responsibility must be developed; the inspiration must come from within. Then and then only would it be easy to keep under control or altogether stamp out any infectious disease before it gets time and opportunity to spread out in an epidemic form.

In order to be able to do this efficiently one must understand intelligently how such infectious diseases are

caused and spread, how they should be recognised, and what precautions must be taken and what dangers must be guarded against, to prevent their extension to the other members of the family and the community at large. With this object in view it is proposed to give a few brief notes on the principle diseases communicable from man to man.

### Cholera

*Symptoms*:—Profuse purging and vomiting of an almost colourless or slightly whitish watery material; muscular cramps, especially in legs; suppression of urine; hollow sunken eyes; anxious look, and collapse. The onset of disease is sudden, and the symptoms very severe from which the disease can at once be recognised. Time is an important factor in saving a life, and the prompt recognition of the symptoms is therefore extremely important.

*Origin*:—The poison consists of very very minute living organisms which enter the intestines and multiply there. A person can be attacked by cholera *only if he swallows these organisms* either with food or drink.

*Mode of spread*:—(a) Water in a river, tank, or well is infected by washing of anything, such as hands, clothes, utensils etc. infected by the living organisms. (b) Food including milk is infected by flies sitting on it, after they have settled previously on discharges of a cholera-infected person, or by the handling of it by hands or in utensils soiled by such discharges even in microscopically small quantities.

*Prevention*:—(a) Personal prophylaxis :—

Never drink water which is not previously boiled or sterilised in any other way. Observe this strictly even in the use of water for washing vessels and washing vegetables to be used in an uncooked state.

Avoid foods that may cause indigestion. Do not use stale food which is likely to be in a state of decomposition. Food-stuffs in a hot state are least likely to be contaminated by flies.

Avoid too much fruit when an epidemic is likely to break out, avoid especially both unripe and over-ripe fruit, avoid *shirbets* of all descriptions. The digestive juice of a healthy stomach is slightly acidic which destroys the germs of cholera. Eating too much fruit or unripe or over-ripe ones tends to destroy this resisting power.

Avoid even aerated waters unless they are carefully prepared at home. Soda water, unless allowed to stand for 3/4 days after it is manufactured, does not destroy germs of cholera, and it is doubtful if it does so even afterwards.

Avoid purgatives particularly salines. The fact that a purgative was taken easily masks the symptoms of cholera, and the doctor may be easily deceived and valuable time lost for administering prompt treatment. Such cases are by no means uncommon and hence this emphasis.

Keep the surroundings scrupulously clean.

Get yourself and all the members of your family inoculated with cholera vaccine, or take anti-cholera Bilevaccine pills and 2 or 3 drops ( only 2 or 3 and no more) of camphor oil to obtain immunity.

If there is a well in the compound of the house for supplying drinking water, sterilise its water in some suitable way.

Notify at the earliest opportunity to the Local Authority and isolate the patient even if it be in a separate room of the same house.

Disinfect every thing connected with the patient, including discharges, clothing, utensils such as plates cups etc.

Let only one person attened on the patient at a time and he or she must wash his or her hands with carbolic soap before touching anything outside the patient's room.

As soon as an attack is suspected, get a doctor to treat the patient AT ONCE. Time is very valuable.

**Plague**

*Symptoms* :—Slight shivering, strong head-ache and restlessness followed by a sudden advent of fever; blood-shot eyes, vacant look; the patient walks and talks like a drunken man.

In the pneumonic variety the lungs are seriously affected, and there is no glandular swelling. This variety though rare, proves generally fatal. In the bubonic plague the glands or buboes appear in 1 to 5 days and are very painful.

*Origin* and *mode of spread*:—The following are some of the important conclusions of the Plague Commission :—

1. Bubonic plague in man is entirely dependent on the rat.

2. Pneumonic plague is highly infectious. It is however, rare (3 p. c. of all the cases).

3. Infection is conveyed from rat to rat, and from rat to man *solely* by means of the rat-flea.

4. A case of bubonic plague in man is not in itself infectious.

The fleas attack rats first, but when they are deprived of their food by the death of rats they attack man. For this reason one generally hears that rats die first of plague and after an interval man is attacked.

*Prevention* :—Prevention and destruction of rats is therefore the only effective remedy. The measures to be adopted must be all directed towards this. They are :

( a ) The building should be rat-proof and rat-free.

( b ) Relieve over-crowding not only of men but also of lumber which favours the harbouring of rats.

( c ) Destroy the rats either by poisoning or better still, by trapping.

( d ) Disinfect the house by means of kerosene emulsion ( see page 250 ) which is an excellent flea-destroyer.

( e ) Keep the house and premises clean. Accumulation of rubbish provides food and shelter for rats.

( f ) Get yourself and every member of your family inoculated with plague vaccine or take anti-plague Bilevaccine pills.

## Enteric Fever or Typhoid

*Symptoms* :—This is rather a difficult disease to diagnose even for a medical man in the beginning. In a typical case the temperature during the first week is continuous and gradually rises to the maximum (103° to 105°) with diurnal remissions. During the 2nd week it remains continuously high with slight diurnal remissions. During the third week the remissions are more marked. In the 4th week first the morning and then the evening temperature becomes normal. Convalescence is said to be

established when the evening temperature is normal for two successive days.

Some diarrhoea is usually present with distension of stomach from the 2nd week, and the stools are yellowish green. The tongue is coated and the eyes are bright and lustrous.

*Origin*:—The disease is caused by specific micro-organisms which infect the intestines, where they multiply and pass through the excreta and urine.

*Mode of infection*:—The most common sources are (a) water, (b) milk and food and (c) flies and dust. The drinking water-supply is often contaminated by sewage, sometimes the excremental matter of a typhoid patient finds its way to wells, tanks, and rivers either directly or indirectly through soiled linen, vessels etc. washed in or near them. Milk is infected by contaminated water directly or indirectly, or by flies alternately sitting on them and on the discharges of typhoid patients. It is also spread by flies and dust settling on slices of melons, *papais* etc. or sweets exposed to air. The last one is common near schools, bazaars, railway platforms etc.

*Preventive measures*:—(1) Boiling of all water used directly for drinking or indirectly for buttermilk, rinsing utensils, and washing vegetables to be used uncooked. (2) Avoiding bazaar-made sweets and cut slices of fruit. This must be enforced in the case of school children during recess hours in particular. (3) Inoculation with anti-typhoid serum or the use of Bilevaccine pills, which give, immunity for a year. (4) Disinfection of all clothing and articles used by the sick. (5) Disinfection of all discharges of the invalid. They should be first mixed with a disinfectant and then buried

on an open ground under at least six inches of dry earth. The discharges of the patient even in the convalescent state contain germs of typhoid. (6) The attendant must keep his or her hands scrupulously clean, especially before taking or serving food, milk etc.

## Small Pox

*Symptoms*:—A sudden onset of high fever with severe head-ache and a severe pain in the back and a flushed face. With characteristic eruption which appears on the 3rd day, first on the face and the wrists, the fever goes down. It is distinguished from measles by the absence of the catarrh of the nose, eyes, and lungs, which is very marked in measles. In the latter, again, the rash appears on the 4th day and with it the temperature *rises*.

It is one of the most contagious diseases. The danger of infection is the greatest when the scales or scabs begin to fall off, and are carried by wind and flies etc.

*Preventive measures*:—(1) Vaccination with a fresh serum, and revaccination afterwards every seventh year. (2) Rigid isolation of the patient. (3) Thorough disinfection of all discharges even of those from the nose and the mouth. Their collection on a piece of cloth and the burning of the latter is the best way. (4) Anointing the patient with carbolised oil and giving him after recovery one or two hot baths, with the whole body scrubbed well with carbolic soap before he is allowed to mix with other people.

## MALARIA.

This disease is too well known to need any description. It is essentially a disease of the middle and poor classes; because the latter do not get nourshing food, nor warm clothing and mosquito nets, nor do they afford to undergo the necessary prolonged treatment with rest, which the disease demands. On account of its very common prevalence, particularly amongst the poor population of the rural districts, it does not attract so much attention and cause a sensation as do the other spectacularly prominent diseases like cholera and plague, but when its far reaching evil effects are considered, it is no exaggeration to say that it is by far the greatest destroyer of the human race.

It saps the vigour, lowers the vitality and makes the community unfit for the battle of life. It not only increases the death rate, but it also lowers the birth rate. It disorganises labour and seriously interferes with agriculture and commerce. It is estimated that it is responsible for over one million deaths per annum in India.

*Symptoms*:—There is invariably an attack of shivering followed by fever. If the latter be high there is a strong head-ache. The fever lasts for a few hours or some times even a day or two and it subsides with profuse perspiration. The subsequent attacks may come daily, on alternate days, every third or fourth day, or irregularly at intervals. In course of time the spleen is enlarged, digestion is impaired, and the person affected loses power of resistance to diseases and falls an easy prey to them.

*Origin*:—The disease is caused by particular germs which live on blood and multiply in it. They are sucked by

the mosquito with the blood of the affected person and when it bites another person in turn, the germs are injected into the blood of the latter. Thus the disease goes on spreading from man to man solely through the agency of the mosquito.

There are two varieties of mosquitoes. 1. the Culex and 2. the Anopheles. The former may disturb one's sleep, but is harmless as far as the propagation of the malarial fever is concerned. It is the latter which carries germs of Malaria. The process of breeding of both the varieties is the same, viz. the eggs are laid in a warm place on, or mostly near, the surface of water; in two or more days they are hatched and the larvæ come out. The latter dive in water feeding on other insects in the water. They come to surface for breathing air. After a week the larva becomes pupa which mostly remains on the surface. After two or more days the skin of the pupa cracks and the adult mosquito emerges. The male feeds on plant and fruit juice but the female sucks blood of some animals including man, and goes to a water surface only for the purpose of laying eggs once in three or four days.

*Prevention*:—There are three ways of prevention. (1) Preventing mosquito breeding, (2) Destroying mosquitoes, and (3) Protecting oneself from their attack.

The first is by far the most efficient. In order that the effort may be directed in the proper way in destroying the malaria carrying mosquitoes, namely, Anopheles, without wasting it in killing the harmless ones viz. the Culex, it is necessary to distinguish between the two varieties correctly. The following are the features which distinguish them.

| Anopheles | Culex. |
|---|---|
| (1) Wings spotted black and white. | (1) Wings not spotted. |

(2) The anopheles sits straight making a definite angle with the wall surface as shown in fig. No. 72

(2) The culex sits in a hunch-backed position with the head and tail thrown down and back raised as shown in fig. No. 73

Fig. 72.
Anopheles

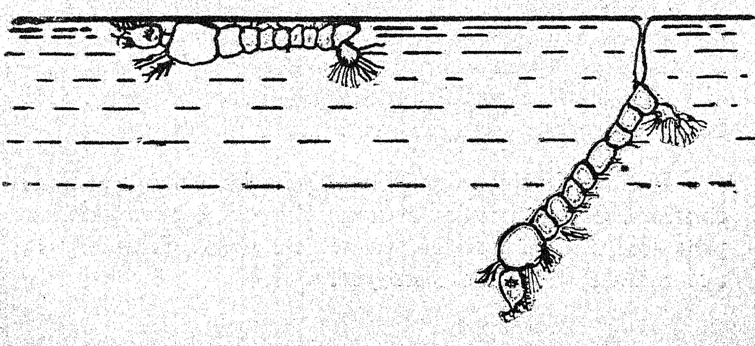
Fig. 73
Culex

(3) The larvæ of the anopheles float immediately below water surface in a position parallel to it, as shown in fig. No. 74

(3) The larvæ of the culex float much below the surface with the head hanging down as shown in fig.No.75

Fig. 74 Anopheles.

Fig. 75 Culex.



| | |
|---|---|
| (4) When moving from its place the anopheles larva darts suddenly with a jerk. | (4) The larva of the culex propels slowly. |
| (5) The anopheles live only in clear water, and move out and bite mostly by night. | (5) The culex lives in dirty water and bites at any time. |

Some of the habits of the anopheles shown above give clues for applying remedies for preventing their breeding. Some of the practical methods are given below :—

The main principle to be observed is that in no event is water to be allowed to stagnate near house; for this, small ponds and pools which are capable of being drained should be drained, and those which are not, should be either filled in with earth or suitably treated so as to prevent the breeding of mosquitoes.

Kundies or small cisterns for slop or household water should be emptied regularly. Water from bathrooms etc. should not be allowed to stagnate on any account, or even to soak into the ground close to the house.

Weeds from nallas having sluggish flow should be removed from time to time as mosquitoes find in them an ideal place for laying eggs upon.

Water troughs for cattle should be emptied and cleaned regularly. Obstructions, if any, should be removed from surface drains and they should be scrubbed occasionally with a stiff cocoanut broom. The eaves gutters should be similarly treated in the wet season.

Hollows in trees should be filled with lime or cement concrete. Old iron tanks, cisterns, tin-pots, broken earthen pots etc. thrown outside, in which water is likely to accumulate, should be destroyed.

Wells in use should be kept clean of any rubbish accumulating on the surface or in hollows and recesses in the sides; as the water is likely to be constantly stirred up while being drawn, mosquitoes will not breed on the surface of wells with clear water.

Unused wells should either be filled up or efficiently closed. No rubbish should be allowed to accumulate in the corners and lanes or narrow gullies between houses as they are bound to retain rain water and form breeding places.

Aroido and other aquatic plants should not be allowed to be planted near the house.

Waste motor lubricating oils, which are otherwise useless, should be poured on the surface of ponds and wells not in use. This oil spreads on the surface in a thin film which prevents the larvae of the mosquito from getting their air supply and in consequense of this, they die. The same purpose is served by kerosene oil but it soon disappears by evaporation and has to be renewed every third or fourth day.

*Protection from the attack* :—(*a*) Using mosquito nets during nights affords considerable protection, but in the first place it is not within the reach of the poor and secondly, for efficient protection not only should the nets have no holes in them, but there should be no opening or door flap in them for entering in. They should be let down in position before dark and should be carefully examined for any stray mosquito that may have intruded, inside before going to bed.

(*b*) Regular use of quinine is another remedy. But this is impracticable, because it entails expense which is often beyond the means of the very poor people though

the Public Health Department have made arrangements to supply it in Post Offices for a trifling cost. Again, it does not agree with the health of many. It is, however useful both as a preventive and a curative remedy. In malarial districts even occasional use of it may help in checking the predisposition to malaria.

## Tuberculosis or White Plague

Tuberculosis is a chronic wasting disease caused by the bacillus called Tubercle. The principal form in which it appears is the pulmonary phthisis, or consumption, in which the lungs are affected. But there are different varieties of tuberculosis each differently named according to the different part of the body it affects. Thus, if glands are affected it is called scrofula; if the spinal chord is affected it is called meningitis and so on. There may be in the same way intestinal tuberculosis, bone or joint tuberculosis, or even skin tuberculosis all caused by the same germ the tubercular bacillus (T. B.) Even lower animals with the exception of the goat are not free from this disease.

*Causes*:—Extreme poverty, ignorance and some peculiar social habits are responsible for the spread of tubercular infection, which has been distinctly on the increase during the last decade as revealed by the last Census Report. Over-crowding and want of nourishment are the direct results of poverty. Over-crowding compels the members of the family to occupy the same room as the one occupied by the consumptive patient. The already inadequate ventilation becomes still less, and the risks of catching infection on the part of the healthy members of the family, increase. The evil is still greater in Northern India and other parts where the extreme cold requires the windows to be shut up during the night time.

The purdah system prevalent in most Mohammedan and a few Hindu communities further increases the incidence of deaths by the disease amongst women and children of those communities. The women folk have to shut themselves up in ill-ventilated, dark rooms on the rear side which is generally insanitary. Then again, on account mostly of poverty and partly of ignorance, the necessary precautions are not taken in the case of the females during and after confinement, particularly in respect of proper medical advice and nourishing food and as a result the incidence of deaths amongst females on account of this disease has, of late years, been very large. There is another reason viz. amongst the middle classes of today on account of unemployment and similar other reasons, purely economical, the age limit of the bridegrooms has increased in undue proportion to that of the brides. This naturally tells upon the health of the latter and creates a predisposition to this disease. At any rate the annual death rate on account of this disease in India is most appalling as compared with the most backward nation in the world. Hence, every effort must be made to educate the public mind in respect of the precautionary measures to be adopted.

*Symptoms*:—The individual affected looks anæmic and pale and lacks vigour. There is a gradual emaciation with decrease in weight and a rise in temperature during night. There are discharges from the parts affected, for instance, purging in the case of intestinal affection, expectoration, in that of the lung affection and so on.

*Mode of infection*:—The germs are passed through the discharges from the affected part. Thus the sputum of the patient of pulmonary phthisis, and bowel discharges of the intestinal affection contain millions of T. B. These germs die out soon when exposed to fresh air and sun's

rays, but they remain active and full of vigour for a long time, in stuffy, dark and damp places. Thus the sputum in a dark corner may have dried up, and still may contain thousands of germs in a virulent state for months together. The dust exposed to sun and open air rarely contains living germs, yet what settles in dark corners and recesses must contain a large number of them. Flies settle on the discharges of the affected person and transmit the germs to articles of food. Even crows and other animals eating sputum in streets, after picking it up fly to a vessel of milk or water and dip their beak into them full of germs, and so on, there are innumerable sources and ways of infection, but by far the most fertile is the sputum. A consumptive patient in open air where the germs are readily attenuated by breeze, is not so dangerous as the one who shuts himself up by closing windows for fear of draught.

*Preventive measures*:—All the preventive measures must be based on two facts known from the life-history of the germ, viz. (1) that fresh air and sunlight are detrimental to the growth of the T. B. and (2) that the disease is disseminated from an affected person to an unaffected one by actual transmission of the T. B.

For personal prophylaxis strictly observe the ordinary rules of personal hygiene viz. (1) sleep with windows open. If draught is apprehended arrange a screen to break its force. (2) Take plenty of open air exercise and (3) Take sufficient nourishment in the food. Besides this observe the following Don'ts:—

(*a*) Don't occupy the same bed with a consumptive patient.

(*b*) Don't occupy the same room with a consumptive patient unless there is a strong current of air coming inside.

(*c*) Don't partake of the milk or food remaining after eeding him; don't use his utensils such as cups, glasses, plates etc. before they are sterilised. It is highly advisable that the patient should have a separate set of utensils for his own use.

(*d*) Don't spit at all. The habit of spitting is very bad. Even an apparently healthy man may be passing T. B. (tubercular bacilli) in his spit or other discharges for years together before he is aware that he has been doing so. The best policy to be observed even on the part of a healthy man is not to spit at all, except into receptacles which can he washed in the ordinary course of household cleaning.

(*e*) Don't eat sweets, cut slices of fruit, pastry etc exposed to air and dust of the streets and to flies.

(*f*) Don't cough, or sneeze into another man's face, always hold a handkerchief against the mouth or nose and turn your face aside.

(*g*) Don't kiss in the lips.

(*h*) Don't blow with your mouth on the surface of milk to keep back cream. Don't blow on hot tea or hot food meant to feed another person, in order to cool it.

(*i*) Don't drop a particle of food or sweets on the floor, and if you happen to drop it, don't pick it up and use it.

(*j*) Don't drink water or any other beverage from the same glass as others before it is throughly cleansed with water. The usual way of cleaning such glasses viz. rinsing the bottom and leaving the part actually held in the lips, untouched, is useless.

(*k*) Don't use ends of garments or the cloth you are wearing for wiping the mouth or hands, either of yourself or those of others.

(*l*) Don't allow dogs or cats to contaminate your food or milk.

(*m*) Don't use road scrapings or dirty earth for scouring or burnishing utensils. Use only ashes from the chulla or earth specially brought from field.

(*n*) Don't forget to wash your hands with soap, once you have entered the patient's room and touched anything there, before you touch anything outside.

*Measures to be adopted by the consumptive patient* :—

These are necessary not only for safeguarding the health of those dear ones who attend on and who come in contact with the patient, but even to a greater extent in the interest of the patient himself to avoid the risks of fresh infection from his own sputum etc. which is bound to retard or even prevent his recovery.

Tuberculosis is a lingering disease and in most cases the purse of a middle class family is overtaxed, often causing them to run into debts. Hence, for their benefit only very cheap but efficient and practical methods have been suggested here below :—

(1) The expectoration when indoors should be received into paper bags, and the latter should be burnt on fire afterwards. It would do if it is received into a glass or china receptacle containing ashes, provided it is emptied into an open pit and covered with at least 4 inches of dry earth, or the contents thoroughly burnt on fire, but the former method is simple and more efficient.

(2) The expectoration out of doors should be received into a kerchief of tough paper (sold cheaply in the market) and the latter should be burnt on fire afterwards as above; or into a large mouthed bottle with a close fitting stopper which should be emptied as above and washed 2 / 3 times with boiling water.

(3) If an ordinary handkerchief is used both indoor and outdoor, it should be kept immersed in boiling water for five minutes *before it gets dry*, and then washed with ordinary soap. If it is allowed to dry, even a slight shaking causes the dry particles of the expectoration to fall off and spread with the wind, and as the latter contain millions of germs there is every risk of the infection spreading to others who get that air into their lungs.

(4) The individual should scrupulously avoid sharing a bed or food with another person. Very often, others do not keep themselves aloof in this way for fear of offending the invalid or to smother his feelings arising out of segregation or boycott. If she be a mother of a young baby she should stop feeding her on the breast in the interest of both.

(5) It is generally not possible for a middle class family to allot an independent room to the tubercular patient particularly in urban area. The member of the family who will attend on the patient (and only one in perfect health should do it) need not be afraid of ocupying the same room provided the room has a sufficient cross ventilation i. e. there are large windows in the walls on the opposite sides, and that they are kept open during night. If the patient is covered with warm clothing, draught need not be feared unless the health is very delicate. In the latter event a screen should be arranged some distance

away from the window on the inner side to break the force of the draught.

(6) The patient's clothing, cups and other utensils etc. should not be mixed up with those in household use before they are kept immersed in boiling water or are thoroughly exposed to direct sun's rays for several hours every day.

(7) No opportunity of admitting sun's rays—no matter if it be possible only in a corner of the patient's room—should be lost. As far as possible the patient should spend most of his time out of doors under the shade of a tree etc. or at least in an open verandah.

(8) The bed room should be cleaned with a wet broom dipped into a disinfectant, or if the floor be of concrete or paved with stone slabs, it should be wiped with a cloth dipped in a disinfectant. In no event should it be swept dry, as the germs in the particles of sputum etc. are likely to be beaten up in the atmosphere of the room and spread.

## APPENDIX No. 3.

### A note on preparing door and window frames of reinforced concrete.

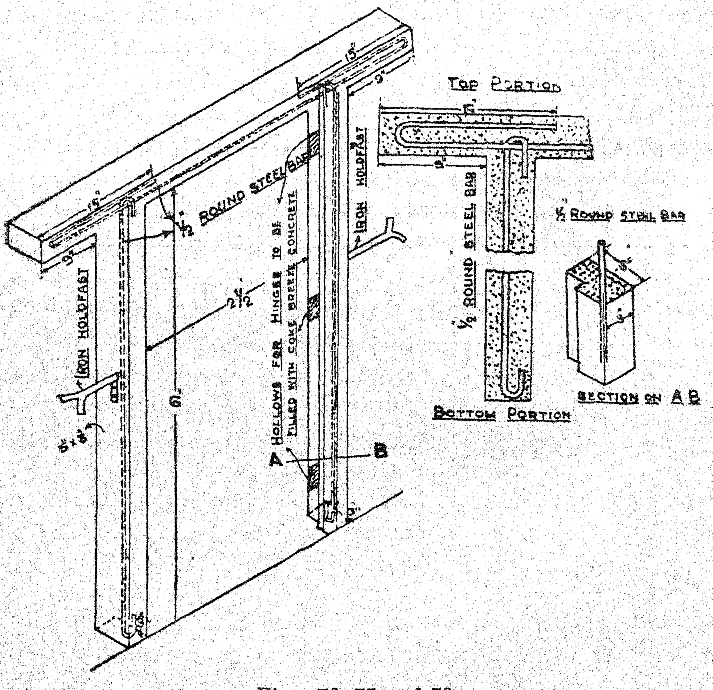
Wooden frames of doors and windows, as they have necessarily to be partially embedded into wall, are subject to the danger of being attacked by white ants and dry rot, particularly when the walls are built either wholly or partially in mud. Again, they are susceptible of being destroyed by fire, if any breaks out. Under these circumstances reinforced cement concrete frames prove to be ideal ones. In some stone districts in India, frames for door consisting of two vertical side pieces and a horizontal lintel above them, all of finely dressed stone 7 to 9 in. square in section, are being used from very old times; but as the shutters cannot be hung on to the stone frames by hinges they are provided with tennons at ends which move in holes in the stone sill at bottom and the lintel at top for opening or closing the door. Another disadvantage of stone door frames is, that as sufficiently long stones for the sides cannot be had at a cheap cost the height of the frames has, in most cases, to be restricted to from 5 to 5½ ft. causing great inconvenience.

Not only can all these defects be overcome by using R. C. C. frames but the latter can be prepared at a less than ⅓ the cost of the teak wood frames. The process is so simple that any lay man can prepare them at home.

It would be convenient if all the doors were made of one standard size, say, 2½ ft. by 6 ft. so that one strong mould prepared, of stout boards 1½ in. thick would serve the purpose. It is economical in the long run if careful

attention is given for preparing the mould, which should be of only well seasoned teak wood.

Figs. 76, 77 & 78 Show an isometric view of such a frame just removed from a mould. It is 5″ by 3″ in section. Any village carpenter should be able to prepare such a mould so as to enclose a space of the section shown in fig. 78. The surface on the inside should be smooth.




Figs. 76, 77 and 78.

The reinforcement consists of mild steel round bars ½ inch diam. with hooks formed at ends as shown in figs. 76 and 77. It is necessary that the hooks at the ends of the top member should be 15 in. long. The two side pieces should be laid flat on ground parallel to each other

at the requisite distance apart and the top piece should be inserted into the hooks and bound to them by means of a thin steel wire.

The mould should be placed flat on ground and crude oil should be smeared with a rag on the inner surface. Then the inverted U of steel bars prepared as above should be laid inside it resting at bottom temporarily on something so as to lie all round centrally in it. Then concrete prepared of 4 parts of gravel, 2 parts of clean sand, and one part of cement, mixed twice in a dry state and twice again with water should be poured into its end and rammed by means of a small wooden handle so as to push the material evenly in every corner and recess. Stone metal and gravel above the size of ½ inch are unsuitable as they do not penetrate into corners and assume a flat surface. The excess material should be removed and top made flat by wiping the top with a straight metal edge. There is no necessity of a covering plank for the top of the mould. After 6 hours the mould should be covered with moist gunny cloth, and left for 24 hours, when the sides of the mould could be taken apart to pieces. After another 24 hours the frame could be bodily lifted up and the bottom plank of the mould removed and used for preparing another frame. If sand and gravel of small size are used, the surface becomes smooth obviating the necessity of plastering it. Should the surface present a rough appearance, a coating of cement one part and fine sand 2 parts mixed in water should be applied with a flat brush. The frame thus prepared should be kept covered under moist gunny cloth for one week. If possible it should be preferably kept immersed in water in a tank or a pond for that period.

For fixing the hinges, rough wooden lugs should be nailed inside the frame at the places of hinges, before concrete is poured so that there would be hollows left at

those places in the frame. These may be filled afterwards with concrete made of 4 parts of coke breeze and one part of cement; when this sets it admits of hinges being fixed by means of ordinary screws as if in wood.

Whereas a teak frame costs about Rs. six per c. ft. including labour, the above frame costs Rs. 1-14 per c. ft. including labour and the cost of the mould distributed over 16 frames, besides being permanent and proof against fire, white ants and dry rot.

## APPENDIX No. 4.

### Remarks and Notes by the Director of Public Health, Bombay Presidency.

*Page 187, Regarding Suggestion for a basket system latrine in Municipal Areas.*

The basket could not be used without a layer of ash or similar absorbent material. For, although the rear chamber is provided with a sump, things should be so managed that as little liquid as possible reaches the sump, the greater part being absorbed in the basket of ash. This system might be considerably improved by providing the basket with a fairly deep layer of fine coke breeze, mixed with ash, so as to act as a kind of filter. Failing this, sand, or porous earth may be used. In these cases the fæces will lie on the surface of the material and be more readily and cleanly removed than if a basket alone were used. The nuisance caused by the liquid in the sump and its removal will also be reduced and even abolished.

*Page 182. Regarding Volunteer organisation vs. Official Agency.*

I agree that volunteer organisations are good for the purpose of spreading knowledge and propaganda in such matters, as it would indicate a real foundation on which the sanitary conscience can be built. But until such development of voluntary social service takes place, official propaganda is a most valuable agency and its efficacy must not be minimised. An official agency is more likely to be correctly informed, not swayed by prejudices, and not activated by personal motives. It is likely to be consistent, uniform, and continuous, and widespread. It is not likely to be limited to isolated

localities where private enthusiasm is active, but will be found equally active in the big town and in the remote village. In Public Health matters wide spread prodaganda and knowledge are essential and this cannot be successfully undertaken by private agency. Both forms have their virtues and one cannot be extolled at the expense of the other. Just as it is necessary to observe personal hygiene and public health, so also, private agency and official organisation are necessary to ensure success in the fight against disease.

*Page 195. Regarding Disposal of urine.*

The urine disposed of in this way will very quickly cause nuisance in the corner of the compound. The urine diluted or otherwise should be disposed of by running it into a suitable soak-pit. It would be cheaper and most efficient to substitute a soak-pit urinal for the type described on this page. One of the smaller types used in the army would be perfectly satisfactory.

*Page 215. Regarding the theory that $CO_2$ is a poisonous gas.*

The "old theory" that carbon-dioxide is a poisonous gas, still holds. It is a poisonous gas in certain concentrations. This theory, however, is not applied now, as the author has rightly stated, to ventilation in the way it used to be. For, whereas before it was considered by itself to be the cause of the various discomforts and disorders that arose from bad ventilation, it is now merely used as an indicator of the presence, in the air, of other agents which are more active in causing the ill effects of bad ventilation than $CO_2$.

*Page 216. Regarding movement of air.*

*Movement* of air or *lack of movement* of air is conducive to a feeling of well being or discomfort, leading in the latter case to serious results. Lack of movement of

air leads to increase in temperature, increass in humidity, which lead to hindrance of evaporation from the body surface, heat accumulation and finally heatstroke.

*Page 222. Regarding "through" ventilation.*

The provision of "through ventilation" by placing ventilators in party walls between adjacent rooms is objectionable. Through ventilation is effected by air passing from one side of a room to another into or out of windows or ventilators placed in the outer walls. This means that the room shall have all its ventilators in direct communication with the outside air space. Verandahs are considered as out side air.

*Page 223. Regarding lofty rooms, vs. low rooms.*

Though a lofty room, on account of its large volume of air causes the respired air to diffuse, still it is to be preferred to a low room in hot countries, first, partly for the reason stated in the paragraph, thus keeping the room cool; second, to prevent radiation or rather minimise radiation of heat from the ceiling, also keeping the room cool. The statement found in English books on ventilation that a height over 14 ft. is of no value for ventilation, is also partly explained by the fact that ventilation and heating in such cold countries are inseparable and there is always much difficulty in heating adequately rooms higher than 14 ft., with consequent trouble with the ventilation.

*Page 231. Regarding self-purification of rivers.*

The self-purification of rivers depends on the quantity of sewage and its nature, the volume of the stream, and the rapidity and turbulency of its flow. Hence, instead of asserting that the water of a river contaminated by sewage becomes quite pure a few miles below, it is safer to say that the quality of the water of a river improves,

the further one goes from the source of contamination and that if no further contamination takes place the water may regain its initial purity.

*Page 240. Regarding Purification of water by bleaching powder.*

The advantage of using bleaching powder for disinfecting water is that its disinfecting action is completed rapidly, in about 20 minutes, and that complete disinfection can be obtained *without* taste or smell or colour. The taste and smell usually experienced in chlorinated water is more due to chloramines resulting from the action of chlorine on organic matter of polluted waters, than to the presence of pure chlorine, which may be demonstrated by other means than taste or smell. Excess chlorination will produce taste and smell of chlorine, but it is unnecessary to proceed to such excess. This is also likely if the water treated is much contaminated as mentioned above.

*Page 245. Regarding dust brought inside the house by feet.*

It is not correct to assume that one must necessarily bring in dirt on one's shoes when one enters a room. With the proper use of a scraper at the front door, and a mat in the front passage, it can be readily demonstrated that shoes are cleaner than the bare feet and that less dirt is carried into the house. By short washing and drying the feet, more dirt is carried into the house on the feet than on shoes.

*Page 250. Regarding efficacy of kerosine oil emulsion.*

Kerosine oil emulsion is not so efficient as it is made out to be. It will act as described only if the emulsion comes into contact with the flea, but not otherwise. Its value as a disinfectant is, therefore, very small, Its value really lies in the necessity for thoroughly washing a room or house which has been treated with it.

*Page 319. Regarding disinfecting clothing, untensils etc. of a cholera patient.*

These should be soaked for two or three hours in a disinfectant and then washed, or boiled for half an hour in the case of clothing etc. ; and for ten minutes in the case of plates etc.

The person attending on the patient of cholera should wash his or her hands in a dilute solution of a disinfectant such as Izal and soap, instead of with mere carbolic soap.

Until the doctor arrives, treat the cholera patient by keeping him warm, and giving him potassium permanganate (keratin coated) pills, or Tomb's essential oil mixture, according to the directions given on the bottle.

It is very important to see that all the patient's discharges are carefully received or collected in a vessel containing a disinfectant, all articles soild by such discharges are thoroughly disinfected, and that nothing that has been infected is disposed of without disinfection.

*Page 320. Regarding prevention of plague.*

In the paragrah *Prevention*, after the words "rats" add "and their fleas".

In para (f) delete the words "or take anti-plague bilivaccine pills."

*Pagc 324. Regarding Malaria carrying larvæ.*

The mosquito larvæ do not feed on other insects in the water, but on minute particles of organic matter, and algæ floating or suspended in the water. Anopheline

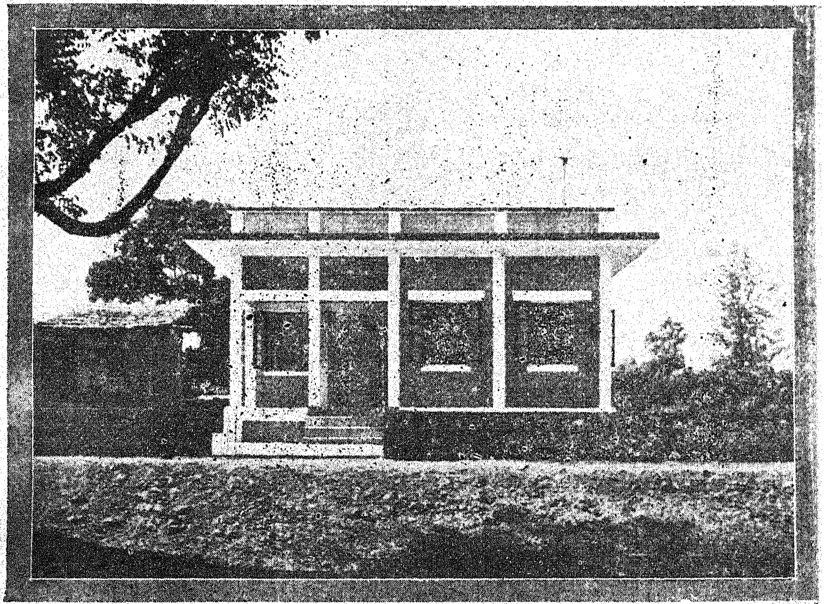
larvæ are surface feeders and it is this habit of theirs that renders them vulnerable to the action of paris green, for, they swallow the fine particles of paris green floating on the water and so are destroyed. Culex larvæ, on the other hand, do not feed exclusively on the surface and so are not affected by paris green.

Culex mosquitoes are by no means harmless. They do not cause malaria, but they cause many other diseases, some of which may be very disabling.

*Page 327. Regarding wells in use.*

Even wells in use will be found breeding mosquitoes, for this reason it is always best to cover all wells and to provide them with suitable pumps.

# INDEX.



**A Concrete Bungalow is a good investment for the following reasons:**

1. Low first cost
2. Negligible maintenance costs
3. Cool in hot weather
4. Warm in cold weather
5. Easily cleaned
6. Rat and Vermin-proof
7. Fire-proof
8. Earthquake-proof

FOR FULL PARTICULARS OF VARIOUS TYPES APPLY TO

**The Concrete Association of India.**

Forbes Building, Home Street,

*Bombay.*

We have illustrated pamphlets on Cement Concrete Construction which will be sent free to interested persons on request.